STRUCTURAL WATERPROOFING

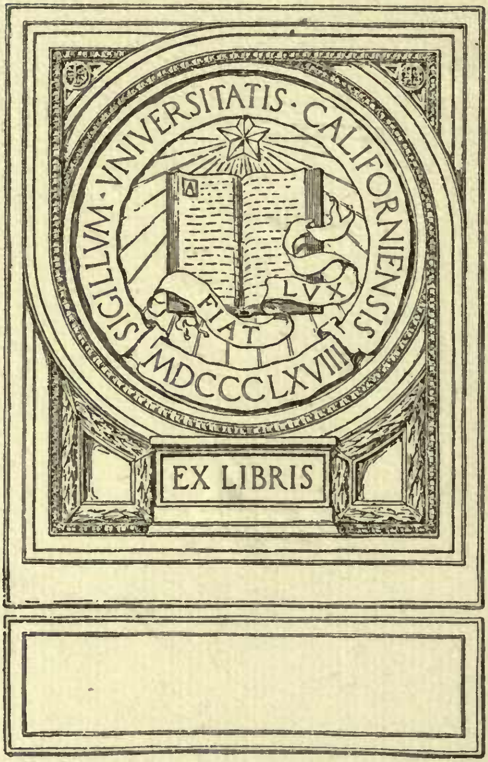
ARCHITECTURAL AND
ENGINEERING EDITION

THE TRUSCON LABORATORIES

WATERPROOFINGS - DAMPPROOFINGS
TECHNICAL PAINTS

DETROIT, MICHIGAN, U. S. A.

PRICE 50 CENTS


SIGILLVM · VNIVERSITATIS · CALIFORNIENSIS
FIAT LVX
MDCCCLXVIII
EX LIBRIS

STRUCTURAL WATERPROOFING

A Waterproofing handbook and reference guide for the use of Architects, Engineers, Building Contractors and others interested in the general subjects of Waterproofing and Dampproofing

Laboratory THE TRUSCON LABORATORIES Quality

THE TRUSCON LABORATORIES

WATERPROOFINGS, DAMPPROOFINGS
—— TECHNICAL COATINGS ——

DETROIT, MICHIGAN, U.S.A.

Table of Contents

Part I

CHAPTER SEVEN

Waterproofing Stucco.

Why Waterproofing for Stucco is Necessary—Penetration of Moisture into Pores of Stucco—Effect on Stucco of Freezing of this Moisture—How Waterproofing relieves this condition—Porosity of Stucco as demonstrated by Test—Circumstances of Test—Practical Illustrations of Unwaterproofed Stucco.

CHAPTER EIGHT

Integral Waterproofing by the Cement Coating Process.

By A. D. Hyman, Chief Engineer of the Waterproofing & Construction Co., New York City.

Introductory Discussion—The Cement Coating Process—Preliminary Steps—Preparation of Surface for Bond—Preparation of Plaster Coat—Plaster Coat Ingredients and their Properties—Thickness of Coat for Walls and Floor—Necessity of Continuity of Plaster Coat—Necessity of Insulating Waterproofing under Abnormal Conditions—Construction Joints between different days' work—How to Eliminate Weaknesses from appearing—Bleeding Walls to Remove Pressure—Construction of Drainage System to eliminate pressure—Concluding Comments.

CHAPTER NINE

Practical Application of Waterproofed Plaster Coat.

Manner in which Wall should be Roughened—Illustration of Roughened Wall—Why a ¾″ Waterproofed Plaster Coat is Adequate—Roughening of Columns and Footings—Application of Waterproofed Plaster Coat to Columns and Footings to Prevent Electrolysis—Results of Plaster Coat Waterproofing—A Typical Illustration.

CHAPTER TEN

Relieving Pressure Before Application of a Waterproofed Plaster Coat.

Method of Draining—Bleed Pipes—Siphon—Central Sumps—Complete Work of Drainage—Bleeding Wall to eliminate Slow Seepage—Practical Illustration of Bleed Pipes—Results of failure to Relieve Pressure.

CHAPTER ELEVEN

Integral Waterproofing a Consistent Principle of Engineering.

The use of the Safety Factor in Engineering Design—Its application to Waterproofing—Engineering not an exact Science—Safety Factor in Reality Factor of Ignorance—Definition of Exact Sciences—Illustrations—Method of Procedure in Exact Sciences—How Engineering differs from Exact Science—Why the Factor of Safety is necessary in Engineering—Concrete offers greatest Variation of all Building Materials—Why it does so—Why the Safety Factor Principle is particularly applicable to Concrete Construction—Direct bearing of this to Waterproofing of Concrete—Concluding Review and Discussion.

Part II

Discussion of Truscon Waterproofing Paste, Concentrated.

Nature of Truscon Waterproofing Paste, Concentrated—How Used—Method of Incorporating Truscon Waterproofing Paste Concentrated in the Concrete—Its Economy—Colloidal Nature of Truscon Waterproofing Paste, Concentrated—Effect on Concrete—General Directions for Use—Table of Quantities—Illustrations—Reports—Testimonial Letters—Prominent Users.

General Specifications for the Use of Truscon Waterproofing Paste, Concentrated.

Specifications for Waterproofing Mass Concrete by Integral Method—Applicable to Standpipes, Cisterns, Reservoirs, Foundations and Similar Structures—Specifications for Waterproofing and General Masonry Structures by means of Waterproofed Plaster Coat—Applicable to Cisterns, Reservoirs, Foundations, Basements, Tunnels, Subways and Similar Structures—Specifications for Waterproofing Cement Stucco.

Part III

Representative Truscon Waterproofing Paste, Concentrated, Installations.

Preface

THIS is the era of concrete construction. For a number of years past the use of concrete as a building material has been growing by leaps and bounds. It is most natural that this should be the case. Concrete is the most ideal building material known. It is durable and fireproof. It provides rapidity in construction and economy in labor. It has, in fact, few limitations.

Its natural absorbent property, however, had a tendency to limit its use in certain directions. There seemed to be no reason, though, why this difficulty could not be overcome and the use of concrete further extended, by eliminating this absorbent characteristic. It seemed logical that the introduction of some element into the concrete during the process of mixing, would accomplish this purpose and add to the other splendid qualities of concrete, the highest degree of impermeability. As later events demonstrated, this proved true, and it is when in a waterproofed state that concrete finds its highest and most complete expression. Out of this idea itself, however, together with its subsequent development, has grown the science of integral waterproofing.

But because of the comparative newness of integral waterproofing as a science, there has been little organized literature or data on the subject. The architect and engineer, faced with a condition where waterproofing seemed necessary, or desiring to extend his use of concrete by some effective system of waterproofing, has found difficulty in knowing where to turn for instruction or suggestion. In other words, the science of waterproofing has lacked a handbook to which the builder could turn as a reference guide.

This Architectural and Engineering Edition of Structural Waterproofing is an endeavor to supply this deficiency and to place at the disposal of the architect and engineer, a thoroughly organized and complete handbook upon the entire subject of integral waterproofing. The theory underlying waterproofing, the nature of waterproofing compounds, a discussion of their chemical and physical characteristics and their practical use in mass concrete, cement plaster coat and stucco, are all fully dealt with in the various chapters of this book. We hope very sincerely that Structural Waterproofing will fulfill a much needed requirement in supplying full information upon the subject, to all persons who may be interested.

We desire to make acknowledgment to Mr. Frank Burton of Detroit and Messrs. H. A. and A. D. Hyman of New York City for the valuable chapters which they contributed to Structural Waterproofing.

THE TRUSCON LABORATORIES

CHAPTER ONE

Structural Waterproofing and Dampproofing

This chapter is designed to show the reader the relation of Integral Waterproofing to the general subjects of Waterproofing and Dampproofing

Waterproofing and Dampproofing—How They Differ—Where each should be Employed—General Classification of Waterproofings and Dampproofings—Graphic Chart—Classifications of Waterproofings—Transparent, Opaque and Bituminous Coatings—Discussion of Various Types of Dampproofings coming under these Classifications—Classifications of Waterproofings—The Integral and Membrane Methods—Various types of Waterproofings included under Integral Method—Integral Powders and Pastes—Various Types of Powders—Colloidal Properties of Waterproofing Pastes—The Membrane Method of Waterproofing—Its Various Usages.

The general subject of structural dampproofing and waterproofing as it confronts us today involves the methods and means of protecting structural materials against the disintegrating action of water. Masonry building materials are generally more or less porous and capillary in their structure, permitting the absorption and permeation of water. The presence of water in masonry is structurally injurious, due to its solvent action on any soluble content, but more particularly its disintegrating action by the expansive force that is manifested by the congealing of the water on freezing. Water that is drawn into foundations from the surrounding soil gradually ascends into the structure, due to the capillary nature of the constructive materials, and finally permeates the entire wall, producing damp and clammy conditions that foster and spread disease. While the subject of structural waterproofing and dampproofing deals primarily with the prevention of gradual decay and disintegration of structural materials, it also performs the useful and necessary function of providing more hygienic conditions for the benefit of humanity in general.

The subject of the protection of structural materials against the disintegrating action of water should, for the most comprehensive understanding, be considered under the two general divisions of Waterproofing and Dampproofing. The term Waterproofing should correctly be confined to the consideration of methods and means of protecting subterra construction and structures intended for retaining and containing water under and against hydrostatic head. Consistent with this definition, the term Waterproofing as a part of this great subject would apply directly to the methods of treating foundations, tunnels, reservoirs, cisterns, standpipes and similar construction. The term Dampproofing should correctly be confined to the consideration of the methods and means of keeping water and dampness out of the superstructure of buildings. In accordance with this definition, dampproofing should involve the various methods of treating exposed walls above grade line to avoid the entrance or penetration of moisture and dampness into the structure.

While there is a slight opportunity for discussion on the absolute literal correctness of the above definitions, nevertheless this division of the general subject serves most admirably to differentiate between waterproofing conditions and dampproofing requirements and to qualify the various materials into either waterproofing or dampproofing products.

It was only a few years ago that in the absence of any comprehensive understanding of this subject, transparent washes were recommended in the literature of manufacturers for treating foundations, tunnels and general subterra construction, with no apparent recognition that such materials have absolutely no application to these severe requirements. By making the above separation of this general subject, and with further sub-division of each individual part, the various materials can be very simply classified and confined for treating conditions where they have a useful and valuable application.

In a paper from one of our larger universities, which recently appeared in the technical press, the following statement was included in the introductory remarks: "Waterproofing materials for use with concrete are divided into four general classes — Membrane, Integral, Surface Washes, and Oil Paint Films." Such a statement can only be confusing, as it does not suggest or indicate any differentiation between the properties of the various materials which are suggested and is, in fact, no more progressive than the general understanding of the subject a few years ago when it was in a rather unfortunate and chaotic condition.

In the absence of a classification of this subject, it is very confusing to the engineer or architect to know exactly what material to select for any particular condition. Naturally, each particular product or method has some special properties that make it advantageous for certain conditions, and at the same time may have limitations that would correctly prohibit its use under certain requirements. Is it not advantageous to the development of this important subject to carefully consider the properties and behavior of each particular method, and so classify it as to be able to select the material and the method that best suit a certain fixed condition?

The architect or engineer will find the following classification of this subject a big advantage in preparing his specifications and also in his general consulting work. As an example: If a client should inquire whether a simple transparent wash was applicable for treating the interior of a reservoir of considerable depth, he could very much simplify his reply with the advice that the method suggested by the client is fundamentally a dampproofing treatment and confined to conditions subjected only to dampness and has no application to a condition where hydrostatic pressure is to be withstood. The client can be easily made to recognize that his condition is literally a waterproofing requirement and that he must employ a method that has actual waterproofing value and not simply a material with such limitations as will only permit its use for dampproofing requirements.

Both the subject of dampproofing and of waterproofing can be sub-divided into various sub-headings, each of which has characteristic properties and insures quite a complete and comprehensive understanding of the full subject. The following discussion develops quite a full sub-classification of the two general subjects, with comment on the distinctive properties and values of each separate sub-class.

The subject of dampproofing, which we have already defined as correctly applying to a consideration of methods and means of keeping water and dampness out of the superstructure of buildings, may be very simply sub-divided into the three following classes, viz:

A—Transparent Coatings and Treatments.
B—Opaque Decorative Coatings.
C—Special Bituminous Coatings.

This classification is quite a complete one and includes practically every treatment that has ever been suggested or used to any practical extent in connection with the treatment of exterior exposed walls above grade line.

Again, the above classification of dampproofing treatments may be further sub-divided. The method involving the use of transparent coatings may be sub-divided into three quite characteristic sub-heads, viz:

(1)—The Sylvester Process.
(2)—Hot Paraffine and Waxes.
(3)—Special Proprietary Products.

(1) The Sylvester Process is one of the oldest dampproofing treatments, and while it has been used to some practical extent, it is at the present time very seldom considered. The Sylvester Process provides for the alternate treatment of a porous masonry surface with solutions of soap and alum. These solutions are preferably applied hot so as to insure good penetration and to accelerate the chemical reaction between the two materials. The theory of this treatment is to provide by inter-reaction of the soap and the alum, an aluminum salt of the fat contained in the soap, which will be deposited in the pores of the surface and tend to repel the moisture. While from a theoretical standpoint, the treatment may appear to be quite an effective one, yet on a practical consideration it is not very satisfactory. It is necessary to make a number of alternate applications of the soap and alum in order to obtain a sufficient quantity of the aluminum soap to provide any repellent or dampproofing action. The number of coats required is made necessary by the fact that the conditions of contact between the wash applications of soap and alum are not such as to insure a good, thorough chemical reaction between the two materials, and there is necessarily considerably soluble material left in the pores that is not utilized, due to the poor and inadequate physical contact.

(2) The second classification of transparent dampproofing treatments covers all of the various methods which have been proposed and used, involving the heating of the masonry surface and the application of melted paraffine or wax. While a dampproofing treatment of this type can be made very effective, its applicacation is necessarily limited to only special cases where the high cost of its application is not prohibitory. The application can only be made slowly, as the surface has to be heated with a blow torch, and only when at the proper temperature can the melted paraffine or wax be applied, to insure the proper penetration and

- Protection of Structural Materials Against Disintegrating Action of Water
  - DAMPPROOFING
    - A-Transparent Coatings and Treatments
      - (1) Sylvester Process
      - (2) Hot Paraffins and Waxes
      - (3) Special Proprietary Products
    - B-Opaque Decorative Coatings
      - (1) Various Cement Washes
      - (2) Common Oil Coatings
      - (3) Special Proprietary Cement Coatings
    - C-Special Bituminous Coatings
  - WATERPROOFING
    - A-Integral
      - (1) Finely powdered dry compounds mixed with dry cement
        - (a) Repellent
        - (b) Non-repellent
        - (c) Metallic
      - (2) Compounds either in liquid or paste form added to water used to temper concrete
        - (a) Unsaturated Colloids
        - (b) Extended Colloids
        - (c) Concentrated Colloids
    - B-Membrane
      - (1) Coal Tar Pitch
      - (2) Natural Asphalts
      - (3) Special Bituminous Compositions

absorption of the repellent material into the pores of the surface.

A very representative incident of the use of this method for preserving masonry exposed to weather exposure is the application to Cleopatra's Needle in Grand Central Park, New York City, in 1885. This obelisk, while resisting the climatic exposure of old Egypt for ages, soon developed indications of rapid superficial decay when subjected to the climatic conditions characteristic of our country. This stone was quite absorbent and as a result of the freezing of water in the pores, the outer surface of the stone was slowly disintegrating. In cleaning the obelisk previous to the application of the hot paraffine, about two and one-half barrels of pieces, weighing a total of nearly 780 pounds, were removed. Some of the pieces were so much decayed and disintegrated that they would crumble easily when removed from the surface. After removing the outer crust of disintegrated stone, the entire surface of about 270 square yards was heated and then immediately treated with a hot solution of paraffine.

(3) The third class of transparent treatments, viz: Special Proprietary Products, suggests quite an interesting and unfortunate chapter in the history of the development of the general subject of the preservation of structural work against the disintegrating action of water. Following the general recognition that one of the objections to concrete construction was its absorbent nature, there appeared on the market an almost innumerable number of transparent liquids presented with the most extraordinary and extravagant claims. According to the literature of the several manufacturers of these products, there was absolutely no condition associated with the general protection against water in constructional work that could not be very effectively and efficiently overcome by a simple application of their product. There was no intent or indication of a proper recognition of the limitations of a transparent treatment, but they were recommended without qualification for tunnels, foundations, reservoirs, tanks, etc., in fact, every single condition that would require waterproofing treatment would find the manufacturers of these transparent treatments recommending their materials.

It will always be the subject of a great deal of regret on the part of all who are vitally interested in the scientific development of this important subject, that the manufacturers of these various transparent treatments did not exercise greater judgment in recognizing the limitations of their products. They were unfortunately prompted alone by the mercenary instinct of a quick return and profit on the sale of their material, not realizing that the ineffective and unsatisfactory results which would follow the use of their materials would tend to establish a general skepticism, and, in fact, disbelief in the efficiency and value of all waterproofing materials.

Practically all of the earlier proprietary transparent dampproofing products were nothing more or less than low melting point paraffines or waxes which had been melted and fluxed back into a volatile solvent. The theory of such a preparation is entirely correct, but unfortunately these several paraffines and waxes can only be dissolved in solvents to a very limited extent, producing a product that actually carries a very small amount of repellent base and an excessive amount of volatile material. On application to the surface, practically 90 to 95 per cent of the original material would be lost by evaporation, leaving only a small residue deposited in the pores of the surface. It would require a number of repeated applications in order to leave deposited in the pores of the surface a sufficient quantity of the repellent base to provide any efficient dampproofing results. Of course, it was usually recommended with these materials that two coats were all that was necessary in order to provide efficient dampproofing results.

There were a few materials that involved a little more technical effort than the simple solution of paraffine or waxes, but in the majority of cases only a small amount of actual total solids was introduced and not sufficient to impart any satisfactory dampproofing results to the surface over which they were applied.

The reason for not making more successful early progress on a transparent dampproofing treatment of this character is unquestionably the fact that the condition is by no means a simple one. A satisfactory transparent dampproofing material that is applied cold with a brush must be one that is practically colorless, as any tendency for the material to stain or discolor the surface is highly objectionable. Nature, unfortunately, has not provided many materials that offer possibilities for producing a product of this kind. The majority of products, when used in quantity sufficient to provide the necessary amount of total solids to give efficient dampproofing results, will impart such a color to the material that when used over stone that is more or less sensitive to discoloration, it will become badly stained, and the injury will be more serious than the difficulty which it was originally intended to overcome.

The repellent base held in solution in such transparent materials must also be of such a nature as will be more or less transparent after the volatile material has evaporated. This is an essential requirement, as the transparent treatments are used quite generally over porous brick or stone surfaces of various colors, and if the coating tends to leave a white deposit after evaporation of the volatile material, it will stand out in contrast to the colored masonry surface and appear as if the surface had a slight efflorescence.

The difficulties which the requirements for such a material presented, and the complaints which followed the use of so many of the inferior products, have resulted in the slow disappearance of a great number of products that originally appeared, and today there are only two or three of the materials on the market that were numbered originally among the great list of special products.

It is a problem that has involved a great deal of careful scientific investigation in order to select such materials which, due to their chemical affinity, can be so combined as to produce a synthetic base which has the properties of dissolving in the combination of solvents, to yield a product that will contain a comparatively high percentage of base so that when applied to a surface and the volatile material has evaporated, there will be a sufficient quantity of material deposited in the pores to fill them and change their natural absorbent nature to a negative repellent action.

B—The second class of general dampproofing treatments, viz: Opaque Decorative Coatings, may be sub-divided similarly to transparent treatments, affording a very simple consideration of this important part of the general subject of dampproofing. This classification is as follows:

B—Opaque Decorative Coatings.
(1)—Various Cement Washes.
(2)—Common Oil Coatings.
(3)—Special Proprietary Cement Coatings.

(1) The first conception of applying an opaque decorative treatment is evidenced in the use of a mixture of cement and water applied with a brush, for the dual purpose of obscuring any imperfections in the surface and giving an outer shell that is of a denser texture, so as to protect the masonry from the penetration or absorption of moisture. While this treatment is more or less effective in uniforming the appearance of the surface, it hardly possesses any great or efficient dampproofing results. This is due to the fact that the cement is mixed with water and when applied the water occupies a definite volume and on evaporation leaves the surface full of small microscopic pores and apertures through which water can penetrate.

There is also considerable trouble experienced in using a cement wash, due to the difficulty in obtaining a satisfactory bond to the masonry surface, if the material is not applied to concrete that has not fully hardened. The usual result with a cement wash is that the coating will be efficient for a little time but after having been subjected to frost when thoroughly wet and saturated, it will be forced off from the surface by the expansion of the water on freezing, and any possible efficiency and value which it might originally have contributed entirely destroyed.

(2) The second class of opaque dampproofing treatments, viz.: ordinary oil paints, has been tried at various times with unsatisfactory results. This is very obviously due to the fact that in contrast to a wood or metal surface, a concrete surface is chemically active, due to the presence of alkali. When a common oil paint is applied over wood or metal, there is no chemical influence to in any way interfere with its normal process of drying to a tough, elastic linoxyn film. When such a product is applied over a concrete surface, the condition is distinctly different.

In the natural process of hydration of Portland cement, there is developed approximately 37 per cent of calcium hydroxide. It is the presence of this calcium hydroxide that contributes a distinctive alkaline nature to concrete surfaces. Any drying oil, such as linseed, is easily decomposed when in contact with an alkali, tending to form a soap of the metal represented in the alkali. In accordance with this natural characteristic of a drying oil, the calcium hydroxide reacts with the oil, forming a calcium soap which entirely destroys the characteristic toughness, elasticity and durability of the product. In place of a weather-resisting and preserving paint film, as would result if the material were applied over a wood or metal surface, only a sticky, incoherent, easily-perishing coating is left, presenting absolutely no dampproofing or uniforming effect.

Periodically we hear from various sources comment in regard to the use of lead and oil on concrete, which may be suggested by an occasional application that is more or less satisfactory. Actually, bitter experience has indicated that an oil paint is not adapted in its constituency to a concrete surface, and so long as a concrete surface is characterized by the presence of alkali—which, in fact, is an inseparable property—it will be impractical to attempt to use a product containing an oil that is so easily saponified.

Common oil paint is generally characterized by a glossy texture which is an objection for treating concrete surfaces. There is stability, strength and endurance associated with a masonry surface, and it is not consistent with good architectural treatment to apply an oil paint coating that will impart a glossy appearance so strongly contrasted to the naturally soft, flat texture of masonry surfaces.

(3) The third method of opaque dampproofing treatments, viz.: specialized cement coatings, offers the greatest opportunity for producing effective and satisfactory dampproofing results. With a full knowledge of the physical and chemical characteristics of a concrete or masonry surface, it is possible to select raw materials and so treat and combine them as to produce a product that is in every sense a specialized cement coating. Such a product cannot be produced by any effort to re-adapt a common oil paint, but must be built up fundamentally from special materials which, due to their physical characteristics and chemical properties, are suited for the production of a strictly specialized product.

C—The third class of dampproofing treatment involves the application of bituminous products to the interior of exposed walls. The treatments in the first two classes as outlined above are applied to the exterior of the superstructure, while the special bituminous products are distinct in being applied to the inside of the wall.

These products are black in appearance and usually of quite heavy body, being applied with a brush so as to provide a thoroughly continuous coating. They are characterized by indefinitely remaining tacky, and provide bond for a coat of plaster applied directly to the coated surface. It is to be emphasized that the prime purpose in the application of such products to interior walls is for dampproofing results, and the fact that they have the associated property of bonding a coat of plaster is distinctly secondary.

It has become a very general practice in construction work to provide for the application of such a dampproofing on the interior of all exposed walls, as it gives an element in the wall that will prevent the continuous penetration of dampness or moisture through the wall, which would injure and destroy the interior decorations and produce a damp and unhealthful condition.

The subject of waterproofing proper, as we have defined applying to the treatment of subterra construction and structures intended for retaining and containing water under hydrostatic head, may very correctly be divided into the two characteristic methods, viz.: Integral and Membrane, each of which has further subdivisions.

The Integral Method of waterproofing involves the addition of compounds to the concrete at the time it is placed, and becomes a unit or integral part of the mass. This method is also known as the Rigid Method of treatment in distinction to the Membrane, which permits greater movement and conformation in the structure without injuring the effectiveness of the waterproofing treatment.

The Integral Method has been received with a great deal of favor by engineers, and its application has been increasing quite rapidly. Undoubtedly the more general selection and specification of the Integral Method in preference to the Membrane, in general substructural concrete work, is due to the fact that the development in the design of reinforced concrete has served to enable the engineer to anticipate his tensile stresses and strain and provide against the rupture or cracking in the concrete by introduction of the proper area of steel. For all concrete construction work where proper reinforcing or provisions are made against cracking, the Integral Method is by far the most satisfactory, due to its greater general economy. Various compounds which are used for general integral waterproofing requirements may be divided into two classes characterized by the physical condition in which they are added to the concrete, viz.:

A—Integral
- (1) Finely powdered dry compounds which are mixed with the dry cement.
- (2) Compounds either in liquid or paste form which are added directly to the water used to temper the dry mixture of cement and aggregate.

The products coming under the first classification may be further divided, due to their characteristic physical properties, into three classes, viz.:

(1)—Finely Powdered Compounds Mixed with Dry Cement.
- (a) Repellent.
- (b) Non-repellent.
- (c) Metallic.

(a) The repellents were the first integral waterproofing compounds to be generally used. These materials are usually the metallic salts of various fatty acids that impart their characteristic repellent properties. The larger proportion of the repellent compounds are the lime salt of a fatty acid, combined with a greater or lesser content of hydrated lime. Such lime soaps were undoubtedly originally chosen as waterproofing compounds due to their characteristic water-repellent properties. The repellent feature of such a compound is an excellent property to possess when the material is uniformly and homogeneously distributed in the mass of the concrete, but its repellent nature makes even distribution quite difficult.

In the practical application of these dry repellent powders, the material is mixed in proportions varying from 1 to 5 per cent with the dry cement. The treated cement is then combined with the aggregate and tempered with water to proper consistency. It develops in practical operations that regardless of the care that may be exercised in the careful and thorough dry mixing of the repellent powders with the dry cement, there is the characteristic tendency to be expelled from the careful mixture when water has been added. This, of course, is particularly true when the concrete is mixed quite wet and there is greater opportunity for flow throughout the mass of concrete. In dry mixtures, such as are quite generally used in facing concrete blocks and artificial stone, the dry repellent powders can be used quite successfully, as the distribution can be maintained by holding the compound entrapped and imprisoned throughout the mass, with no opportunity to manifest its repellent properties, due to the dryness of the mixture. For general concrete operations, however, the repellent properties are greatly limited, due to their repellent action. The presence of quite a large percentage of hydrated lime is essential to serve as a ballast for the repellent material.

(b) The objection which has been taken by the engineering fraternity to the use of repellent products on account of the uncertainty in uniform results, has been a natural incentive to develop products which do not show this repellent action. These products are usually constituted on a basis of hydrated clay, aluminum hydroxide or some similar inorganic colloidal substance. In manufacture they are ground extremely fine so as to develop the largest possible surface area to intensify colloidal development. The partial efficiency of such materials is contributed by their void-filling value. They are also recommended as beneficial in lubricating the mass of concrete so that it flows together in a tighter and closer mass.

The limitation of such materials is due primarily to the fact that the products which are used, while of a characteristic colloidal nature, have not the capacity for sufficient colloidal development to fill out all the voids and apertures of a concrete mass and give a density that is absolutely impermeable. There is also considerable doubt in regard to the permanency of the colloids, due to the fact that when given opportunity of drying out there is some difficulty and delay experienced in their reverting back to their original colloidal volume.

(c) To complete the classification of various integral waterproofings which are mixed with the dry cement, metallic compounds should be mentioned. These products consist primarily of very finely ground metallic iron, and in their integral application are mixed dry with the cement in a similar procedure to other dry integral products.

The theory of the action of such products is the increase in volume that occurs from the oxidation of the iron. When the process is complete, in place of the fine particles of iron, there is developed the hydrated oxide, which occupies a volume much larger than is the case with the original iron particle. The great difficulty, however, in obtaining satisfactory results with the metallic powders when used in integral application is the fact that cement itself is strongly basic and the presence of the hydroxyl ions developed in the crystallization of the cement naturally inhibits corrosion and prevents the oxidation and development of the iron throughout the mass of concrete, which is essential for efficient results.

The second class of integral waterproofing compounds which are added directly to the water, either in liquid or paste form, has the great advantage of absolute certainty in even, uniform distribution throughout the concrete. These products are generally readily miscible with water, forming a colloidal suspension in the water, and as a result of thorough mixing of the water with the cementing materials, are correspondingly uniformly distributed throughout the entire mass. The compounds in this class may for the most complete consideration be divided into the three following classes:

(2)—Compounds in liquid or paste form added directly to water used to temper concrete.	(a) Unsaturated Colloids (b) Extended Colloids (c) Concentrated Colloids

(a) Under this class are included practically all compounds which contain unsaturated fatty acids that require reaction with the constituents of the cement in order to form the final waterproofing compound. These products are usually mixed with the water used to temper the concrete in proportions varying from 1:25 to 1:50.

The great general objection to the use of unsaturated colloids is the uncertainty of the effect upon the tensile and compressive strength of the concrete. The one constituent in the cement that is most reactive with the fatty acids in these unsaturated compounds is the calcium hydroxide, which also plays a very important part in the normal setting and hardening of the cement. The utilization of a portion of the calcium hydroxide for reaction with the unsaturated compound to form a waterproofing colloid will proportionately detract from the strength which the calcium hydroxide is intended to contribute in the normal hardening of the cement.

(b) Products included under the classification of extended colloids are not usually characterized by any tendency to enter into reaction with the constituents of the cement, but contribute their efficiency by the characteristic colloidal nature of the compounds themselves. The limitation of the extended colloids is in the fact that in the process employed in the manufacture of the products, there is invariably associated with the extended colloidal compound more or less inert material which is not particularly beneficial in contributing waterproofing value. The presence of varying percentages of inert and inactive materials associated with the colloidal compounds naturally makes these compounds uneconomical, as they must necessarily be used in quite rich proportion in order to carry in sufficient of the colloidal substance to give satisfactory waterproofing results.

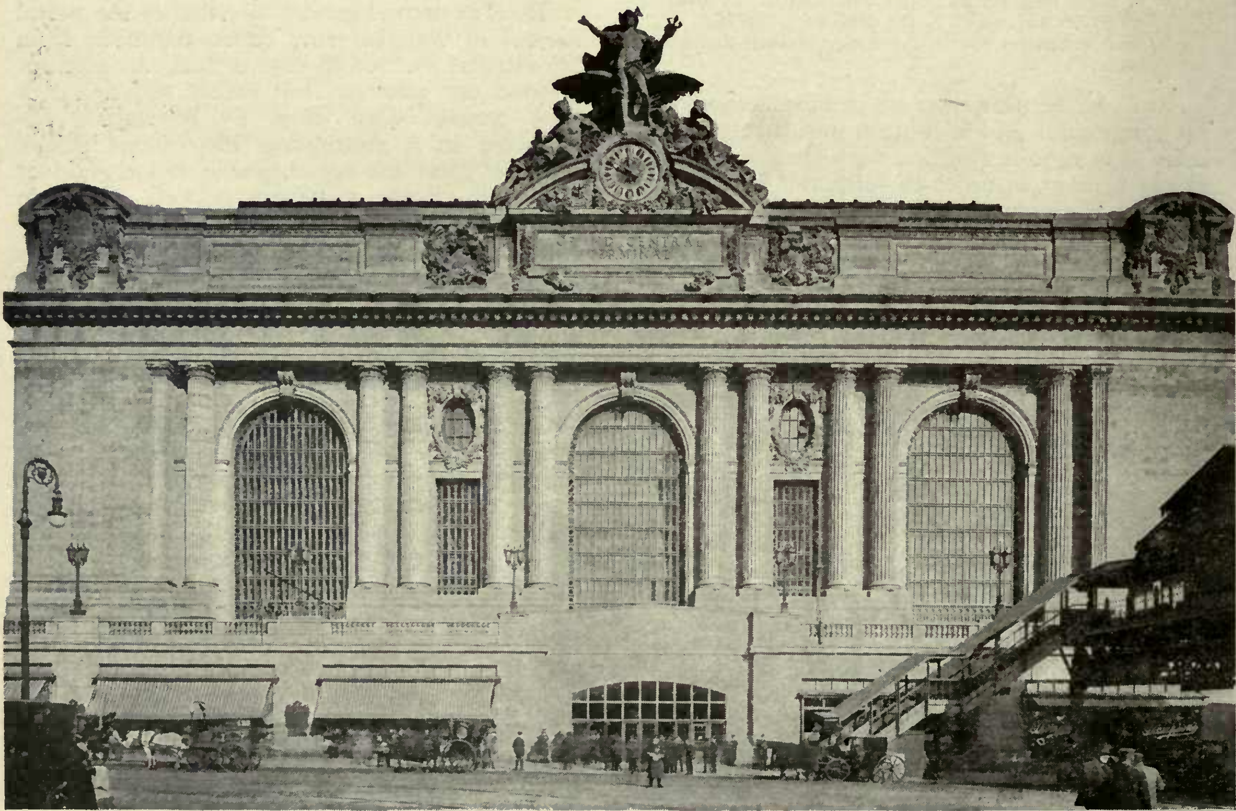
(c) The products included in this class are a further development of the extended colloids in that they contain only materials of a strictly colloidal nature, which are capable of contributing waterproofing value. In their manufacture the inert and inactive materials have been eliminated, so that the final product contains only colloidal substances and so combined as to develop the maximum colloidal value. The fact that such products are concentrated affords the maximum economy, as they can be used in leaner proportions and still provide the colloidal volume that is essential to fill out all the pores and apertures in the concrete and give the density necessary for impermeability.

B—The second general division of the literal subject of waterproofing differs distinctly from the integral method in that it does not attempt to treat the concrete, but rather to insulate it from contact with water by enveloping the structure in a continuous bituminous shield. The fact that the membrane is not a rigid or unit part of the structure permits a certain freedom of movement and action in the concrete without impairing the efficiency of the waterproofing treatment. This feature of the membrane system makes it suitable for waterproofing work not fully reinforced and liable to settlement or subject to vibration or shock, such as a railroad bridge.

It was early practice to simply coat the surface to be waterproofed with hot tar or asphalt, but it soon became evident that this was not sufficient, as the coating would crack with any movement in the wall. It was, therefore, necessary to employ some material in addition to the bitumen in order to contribute the necessary toughness and tensile strength. Burlap and coal tar felt have been extensively used for this purpose and some very satisfactory waterproofing operations have been carried out with such materials. During the last few years considerably more attention has been given to the nature of the waterproofing felt, and as a result there are now on the market especially manufactured felts which are both saturated and coated with bitumen and possess greater pliability and strength. By means of these felts more perfect membranes can be constructed, as the strength and toughness of the felt permit greater distortion and twisting to accommodate it to the design of the work.

The bitumens most generally used for cementing the felt together in constructing the membrane are coal tar pitch, commercial asphalt and special asphaltic compositions. While the general method in the application of the reinforcing felt and fabric with the bitumens is practically the same with all of the materials, there is considerable discussion in the engineering fraternity at the present time regarding the bitumens that are the most satisfactory. The discussions primarily concern the treatment of overhead railroad bridges to protect the public from dripping and also to protect the steel from corrosion. At the present time there is quite an apparent diversity of opinion among railroad engineers as regards the selection of the bitumen that is best suited for this treatment. The present consensus of opinion seems to favor the use of asphalts when exposed to the air, as they are more resistive to oxidation than is the case with coal tar products. The coal tar products are given preference in their application to subterra construction, where they are covered with earth filling and not exposed to free oxidation. In selecting any bitumen for waterproofing purposes, care should be taken to obtain a material at as low a melting point as the nature of the work will permit, as it not only insures greater elasticity when subject to cold temperture, but works much more freely and easily in applying.

The special asphalts which are used quite generally for membrane waterproofing are usually manufactured from a hard hydrocarbon, such as gilsonite, tempered with a petroleum residuum to impart the necessary elasticity. The residuums used in the preparation of these asphalts should be preferably strictly asphalt bases and contain the minimum percentage of paraffin which, being of a lubricating nature, impairs the necessary bonding properties of the asphalt.



The Grand Central Terminal, New York, N. Y.

Service Room floors waterproofed with Truscon Waterproofing Paste, *Concentrated.*

CHAPTER TWO

Analytical Reasons for the Necessity of Incorporating a Waterproofing Compound in Concrete

Importance of density in structural materials for Strength and Resistance—Danger of Porosity—Causes of Porosity—Examples—Porosity of Concrete—Why Concrete is Porous—Function of Integral Waterproofing in eliminating Porosity—Importance of Repellancy in Integral Waterproofing Compounds—Importance of Colloidal Properties in Integral Waterproofings.

In determining the strength and resistance of structural materials, one of the most important properties to consider is density. With density are associated solidity, strength and endurance. Contrasted with density, considered as the proportion of mass or quantity of matter to volume, porosity would represent the actual unoccupied space in the total volume. With porosity are associated weakness, deficiency and decay.

The metallic structural materials, such as iron and steel, have the highest densities. In the processes employed in the manufacture of steel, the conditions are all favorable for producing a product of high density. Also, in the subsequent rolling and shaping of the metal the treatment is one tending in the direction of greater density and greater compactness. In the process of cooling after the metal has been poured in the forms, also in the treatment which the metal receives in the process of rolling and shaping, there is no substantial evaporation or volatilization of any constituent or inherent part of the metal. In the absence of elimination of any constituent part after the metal has taken definite shape or definite volume, there is no opportunity for developing unoccupied space or volume so as to impart porous characteristics to the metal. The constituents and elements of the metal are fixative and there is no characteristic elimination of any substance by any processes that would develop porosity.

It is also characteristic of various rocks that are employed extensively in construction work to possess a high ratio in the proportion of actual mass or quantity of matter to bulk or volume. This high density is due to the fact that in the mineralogical formation of the rock the processes were such as tended to fill out with mass all available volume and not leave any unoccupied space in the final formation.

In structural materials as well as the majority of other substances which are characterized by low density, the porosity is generally formed by the elimination, either by volatilization or evaporation, of some original constituent of the particular substance.

Charcoal is a characteristic porous substance. Charcoal, as is general knowledge, is prepared by the dry distillation of wood. Wood in the original form consists of cellulose, resins, lignine, and various inorganic salts and water. After dry distillation at a temperature of 400 to 450 degrees Centigrade, which is the characteristic temperature in the preparation of charcoal, all of the volatile matter is driven off and the residual charcoal consists of practically the fixed carbon and the inorganic constituents of the wood, representing only about three-fourths of the volume and usually about twenty per cent of the weight of the original wood.

Similarly, our common coke is manufactured by the destructive distillation of coal. The actual porosity of the coke will naturally depend upon the nature of the coal from which the coke is produced. With anthracite coal the volatile hydrocarbons are low, while with bituminous coals the volatile hydrocarbons are high, and the actual porosity or unoccupied volume in the coke will be in direct proportion to the percentage of volatile hydrocarbons which is eliminated in the distillation of the coal.

Quick lime serves as an excellent example of a substance of low density, due to the high porosity resulting from the elimination of the carbon dioxide from the limestone burned to produce the quick lime. As a result of the loss of water, organic matter and carbon dioxide during the burning of limestone, there is a great reduction in the weight of the original material, but only a slight decrease in its volume. As a general case, 100 pounds of good limestone yield about 58 pounds of lime, but the shrinkage in bulk is not over 10 to 15 per cent of the original volume of the limestone. The small reduction in volume during burning, compared with the big loss in actual weight, indicates the development of a very porous structure in the quick lime in direct proportion to the volume left unoccupied by the elimination of the constituents driven off in heating.

The porosity of our common burnt brick is largely in proportion to the water, inorganic matter and gasses which result from the decomposition of the carbonates and similar minerals present in the clay. While the brick after being pressed is quite compact and dense, after being burned the structure is quite porous, due to elimination of the above substances.

It is to be emphasized in citing the above examples that in a large number of cases the actual porosity of a substance is in direct proportion to the original constituents which are eliminated by natural evaporation or in gaseous form under the action of heat. With steel there is no constituent for substantial evaporation after the material has reached the molten state, and every treatment is one to produce compactness and density, while with charcoal, coke, lime, brick, etc., the treatment in manufacture involves the evaporation and elimination of a large percentage of the original constituency, leaving an unoccupied volume or porosity in proportion to the eliminated elements.

Porosity, therefore, in connection with various substances can be quite accurately defined to be in direct proportion to the volume left unoccupied by the evaporation or elimination of an original incompressible constituent.

According to this reasoning, the porosity of concrete would be substantially in proportion to the volume in the mass left unoccupied by the evaporation of the larger portion of the water which is an inportant constituent of the original concrete. The function of the water used for tempering and mixing Portland cement concrete is both physical and chemical. A comparatively large excess of the water is required for the physical function of providing a somewhat liquid consistency that will permit the placing of the concrete in forms and its spading and tamping to produce the greatest compactness. Water is also necessary to enter into chemical reaction with the cement to provide for the natural solution and hydration of the cement essential to form the necessary crystallization to bind and cement together particles of inert aggregate. In the chemical changes a portion of the water actually becomes a constituent part of the final composition of the hydrated cement, but the larger percentage is unnecessary for hydration and is eliminated by natural evaporation, depending upon the mass of the concrete and the existing temperature.

In general concreting practice between 25 and 30 gallons of water are employed for tempering a cubic yard of 1:2:4 concrete to a medium wet consistency. Taking 27.5 gallons per cubic yard as an average, and the weight of water at 8.34 pounds per gallon, there would obviously be introduced into each cubic yard of concrete approximately 229.35 pounds. As water under normal conditions of temperature and pressure weighs 62.5 pounds per cubic foot, the 229.35 pounds would be equivalent to 3.67 cubic feet of water. According to this calculation, approximately 3.67 cubic feet of water are used for tempering concrete comprising one cubic yard.

Estimating liberally that 25 per cent of this water would be utilized in entering into actual chemical reaction with the cement in the processes of hydration, there still would remain 2.75 cubic feet of free water. Also making a further liberal allowance that 25 per cent of the 3.67 cubic feet of water is retained in the colloidal development of the cement, there still remains an absolute minimum of 1.84 cubic feet of water to be eliminated by evaporation. This is a little less than seven per cent of the total volume, which would be left unoccupied by the evaporation of the water. This factor agrees quite favorably with observations that have been made to determine the actual absorption of a thoroughly dry concrete.

It is the function of an integral waterproofing compound to occupy the volume left free and unoccupied by the evaporation of the water. The integral waterproofing compound should correctly exhibit some repellent action after it has been uniformly distributed throughout the concrete. The development of this repellent property is an advantage in preventing the absorption of water into the capillary structure of the mass.

More important is the necessity of the integral waterproofing compound possessing colloidal properties or capacity of retaining a larger percentage of the water to provide for full colloidal development of the integral waterproofing compound, in order that through its voluminous development all the pores that would otherwise be left free and open may be occupied and full density provided.

CHAPTER THREE

The Physical Characteristics of Integral Waterproofing Compounds

Waterproofing Powders and Pastes—Methods of Introducing Waterproofing Powders into Concrete—Theory underlying Waterproofing Powders—Behavior of Powders in practical use—Various types of Powders—Methods of Introducing Waterproofing Pastes into Concrete—Behavior of Pastes in practical application—The Simplicity of Pastes—Illustrations.

With the rapid increase in the popularity of the integral method of waterproofing, there has occurred an interesting evolution in the nature and characteristics of the integral waterproofing compounds.

In the integral method the waterproofing compound is introduced directly into the mass of the concrete, and the thoroughness with which it is distributed throughout the mass depends very largely upon the physical characteristics of the compound.

The method by which the integral waterproofing compound is introduced into the concrete mass serves as a very simple, general means of classification of the various integral products. This classification would include the two general heads of finely powdered dry compounds which are mixed directly with the dry cement, and a second class of compounds which, in either liquid or paste form, are added directly to the water used to temper the concrete.

The compounds furnished in finely ground powder, which must be mixed evenly and uniformly with the dry cement, represent the earlier conception of the requirements of an integral waterproofing compound. In the practical use of these compounds, from two to five pounds of the material are recommended to be mixed dry with each bag of cement. To insure effective mechanical distribution, it is necessary that the required amount of material is thoroughly dry-mixed with the cement. This operation generally involves considerable labor and has proved one of the serious handicaps which has retarded the more extended use of the dry compounds.

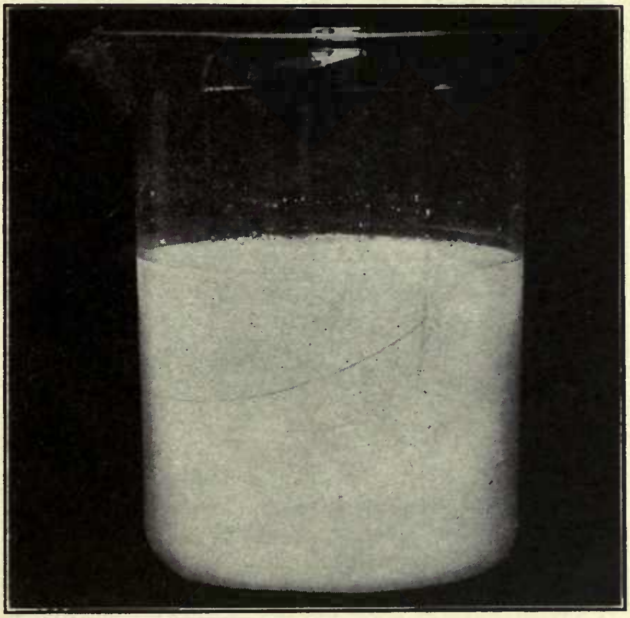


Figure 2.

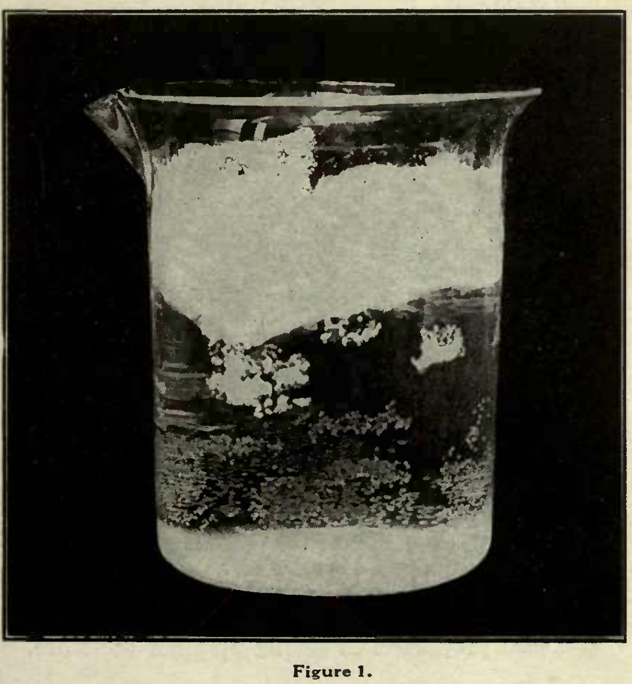


Figure 1.

The compounds included under the general class of dry powders which in application must be mechanically mixed with the dry cement can, for the most comprehensive consideration of their physical properties, be divided into repellents, non-repellents and metallics. All of the various dry powder compounds, considered from the standpoint of their physical characteristics, are included under one of the above-mentioned classes.

The compounds which are characterized by a repellent action to water were among the first of the dry powders that were generally used.

The repellent properties of these compounds are contributed entirely by the presence of metallic soaps which have the inherent characteristic of being immiscible with water. It was only quite natural that these dry repellent soaps would be among the earlier conceptions of the integral waterproofing, as the interesting property of being immiscible with water would readily suggest that they possessed advantages in repelling

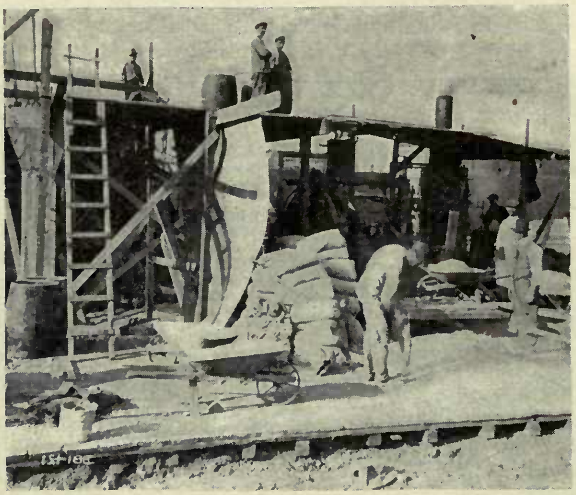


Figure 3.

water from entrance into the concrete, if they could be introduced in a uniform distribution throughout the concrete mass.

While theoretically this conception seems excellent, yet in practical operations it has been repeatedly demonstrated that the repellent nature of the compounds is exactly the characteristic that prohibits even and uniform results. Regardless of the care that may be exercised to insure the most even and uniform mechanical mixing of the repellent compound with the dry cement, when the cement is tempered with water the compound has the marked tendency to separate out, due to its immiscibility with the water.

Figure No. 1 shows an interesting experiment to demonstrate the marked repellent nature of these compounds containing metallic soaps. To a beaker about two-thirds full of distilled water was added a weighed amount of a representative repellent compound. The mixture was subjected to very vigorous mechanical agitation for several hours, and at the conclusion practically all of the repellent compound was still retained on the top of the water, showing no tendency for mechanical mixing with the water. It is exactly this repellent feature, which in earlier conception seemed a valuable characteristic, that has proven a serious objection to the use of such compounds.

An interesting analogy emphasizing the physical behavior of the repellent compounds would be the result of an effort to keep finely ground cork distributed throughout the mass of the powder with which it was originally mixed dry, when water was added to the powder so as to produce a thin paste. Very naturally the cork, due to its lighter gravity and its repellent action, would separate itself from any uniform mechanical distribution that might have originally been provided, and tend to collect on top of the water.

Quite naturally the extent to which the dry compound or repellent product will be ejected or expelled from its mixture with the cement will depend upon the consistency to which the concrete mass has been tempered with water. With very dry mixtures the compound will be held mechanically entrapped, but in mixtures that are sufficiently wet to be consistent with those generally used in practical concreting, there is enough opportunity for movement in the mass so that the even distribution of the repellent compound will be destroyed by its natural tendency to stratify and segregate throughout the mass.

The second class of dry compounds that are added directly to the cement is a very natural evolution developing from the observed behavior of and the objections to the repellent compounds. With these non-repellents there is naturally no difficulty experienced in maintaining uniform distribution in the cement, as they are as thoroughly miscible with water as the cement itself.

One of the interesting features that is claimed for these dry compounds is that due to their colloidal nature they serve as lubricants and provide greater density due to the greater compactness of the concrete. This lubricating characteristic, intended to bring the particles of aggregate and mortar in closer contact, is doubtless one of some consideration, but this simple property of an integral product is not the prime function in determining the effectiveness with which the concrete is rendered waterproof. An integral waterproofing to be effective must serve to accomplish a great deal more than simply providing a little freer consistency in the concrete that will insure its flowing together to a little tighter and closer mass.

The important limitation of the non-repellents is due primarily to the fact that the compounds are not of such a nature, nor do they lend themselves to any treatments that will insure the development of their colloidal properties, which according to the latest conception of integral waterproofing are essential for thoroughly effective results. While the compounds may originally have some colloidal properties, the non-repellents are characterized by colloids which are termed technically non-reversible. On the drying out of the concrete there is a tendency for the non-repellents to lose their colloidal properties in giving up their moisture.

In this condition, even though the concrete may again become wet, the non-repellents are extremely slow in reverting to their original state and in some cases it is questionable if they have any property of returning to their original colloidal condition, in order to develop to the necessary volume to fill out and occupy all the internal voids and interstices, essential to give a density that will be impermeable.

For completeness in the classification of dry powder compounds that are added directly to the dry cement, mention should be made of the metallic products. These compounds have contributed very little to successful integral waterproofing treatments, due primarily to the fact that they are composed largely of finely ground metallic iron. When mixed with cement and surrounded by an alkaline medium, there is no opportunity for corrosion or development of the physical volume of the iron, and they remain only as inert, inactive, mechanical fillers of practically no more advantage in the mass than fine aggregate.

The second general class of integral compounds, namely the products which, either in liquid or paste form, are added directly to the water used to temper the concrete, marks the most important and valuable improvement in the subject of integral waterproofing. The objection of the contractor to the added labor cost and effort involved in the dry mixing of the powder compounds with the cement, and the intelligent criticism of the architect and engineer in recognizing the impracticability of keeping such compounds properly mixed with the mass, were fully met and solved by the introduction of products which are added through the medium of the water.

Figure No. 2 illustrates an easily conducted experiment which very clearly emphasizes the practical advantages of the compounds which are added directly to the water. In this experiment one part of a compound in paste consistency was added to twenty-four parts of water, and after very little agitation produced an even, uniform mixture of milky appearance. In this particular experiment the compound remained for several hours in suspension, demonstrating that on addition to the water the paste compound formed an almost perfect colloidal suspension in the water.

Figure 4.

It is obvious that a paste compound of this nature which, with very little agitation, becomes so thoroughly and uniformly mixed with the water, with which it indefinitely remains in suspension, will through the medium of the water be carried throughout the entire mass of the concrete and give a thoroughly uniform waterproofing result.

In practical work the operation of the introduction of the paste compounds which are miscible with water can be very simply conducted. Figure No. 3 illustrates a concreting plant where a temporary platform has been constructed above the mixer. This platform should be built strong enough so as to support the weights of a barrel of the waterproofing compound, two barrels of water, together with the weight of usually one workman, who will provide for the mixing of the paste with the water in proportions in which it is recommended to be used.

Figure No. 4 illustrates the simple method of providing for two empty barrels, each connected by pipe so as to deliver its contents directly into the mixer. While the mixture of paste and water in one barrel is being used for tempering the concrete in the mixer below, a new mixture of paste and water can be prepared in the second barrel, and by this alternating process one barrel will always be in readiness for use and there will be no opportunity for retarding or in any way delaying the concreting operation.

While the illustration shows two workmen on the platform mixing the paste compound with the water, it is generally accomplished by one man, as the paste compound, to be a thoroughly effective and practical one must mix with the water easily, so that the whole operation involves only placing a measured quantity of the waterproofing in the barrel and then filling the latter with water from a pipe connection that is provided on the platform.

This method of introduction of the waterproofing compound naturally appeals to the contractor, as it is one that requires very little additional labor cost, since the manipulation is so easy and simple. It in no way interferes with the rate or speed of mixing the concrete, as the workman on the platform will always have the mixture of paste and water in proper proportion ready, and by being elevated above the mixer is not in the way so as to interfere with or complicate the conveying or depositing of the concreting materials in the mixer.

The efficiency of the various integral waterproofings which are added either in liquid or paste form directly to the water is naturally governed by their chemical composition. This is disscussed in the following chapter.

The Colloidal Behavior of Integral Waterproofing Compounds

Significance of Colloidal Characteristics as applied to Integral Waterproofings—Difference between Portland Cement and Plaster of Paris—Presence of Colloids in Portland Cement—Semi-Waterproofness of Portland Cement Mortar due to presence of Colloids—Addition of sufficient more Colloid to produce complete Waterproofness—Types of Colloidal Material which will produce most complete and permanent Waterproofing results—Manner in which they should be introduced into the Concrete.

The significance of colloidal characteristics as applied to integral waterproofings has developed with the increased knowledge on the technology of Portland cement. Prominent among the students of the technology of Portland cement is Doctor W. Michaelis, Sr., who through his masterful work has given science a great deal of additional valuable information on the true constitution of and the processes which occur in the hardening of hydraulic cements.

Doctor Michaelis has very convincingly shown in his investigations that in the processes that characterize the hardening of Portland cement, there is, in addition to the crystallizing processes which have been brought out by earlier investigators, a characteristic colloidal action which actually serves a very important function in the hardening and contributes very important properties to the hardened body.

Portland cement considered as a product hardening by crystallizing action alone, its general characteristics would be quite similar to those of plaster of Paris, which is also a hydraulic material. It is common knowledge, however, that any composition of which plaster of Paris is the sole cementing agency does not possess the property of resistance to continued weather exposure. The most important reason to explain the characteristic weather- and time-resisting qualities of Portland cement mortar or concrete as compared to a plaster of Paris mixture is the presence of the colloidal substance that is formed in the process of hardening of Portland cement, in addition to the crystallizing action, and which is not a characteristic of plaster of Paris.

Chemically, the colloidal body that occurs in the hardening of Portland cement results from reaction between the silica and lime forming a calcium silicate. The fact that the product is formed in the presence of an excessive amount of water, provides for more or less water entering into the composition of the compound, which, due to the rather energetic and rapid reaction, forms a highly developed colloidal body, giving in its accurate technical nomenclature a colloidal calcium hydrosilicate. For simplicity, Doctor Michaelis refers to this colloidal body as a hydrogel, and the greater number of its more general characteristics can be better visualized by conceiving this compound as a glue or jell.

As stated above, a great many of the puzzling behaviors of Portland cement when applied in construction work as a mortar or concrete are quite clearly and fully explained by understanding the characteristic behavior of this hydrogel. Various observations in the cracking of mortar and concrete which have been quite difficult to explain by thermal action or other natural causes, are quite clearly understood by applying the knowledge of the characteristic expansion and contraction of this hydrogel. The unusual development of cracks in Portland cement concrete or mortar is quite generally the result of rapid shrinkage or contraction of this colloidal substance. Also, cracks developing from an internal expansion are quite generally due to the development of the colloidal substance, usually in contact with water. In fact, the activity of this colloidal substance is quite directly a function of the presence or the absence of water. The volume changes in Portland cement concrete as affected by the presence of water acting on this colloidal substance are very thoroughly and splendidly discussed, together with data on accurately conducted observations, in an article presented to the 1914 meeting of the American Society for Testing Materials and reported in volume fourteen of the Proceedings of this Society. This article clearly and convincingly presents the behavior of Portland cement in reaction with water, expanding and contracting under various conditions, influenced by the characteristics of the colloid.

A careful study of the behavior and influence of this naturally occurring colloid in Portland cement mortar develops some very important and significant facts as regards the correct properties and behavior of an integral waterproofing product in order to be effective and satisfactory in imparting perfect density to Portland cement mortar or concrete. Fundamentally, an ideal integral waterproofing should be of colloidal nature in order to serve most effectively in filling in the voids and interstices left between the interlacing and interlocking of the crystals formed in the hardening.

While the natural gelatinous and glue-like characteristics of a colloidal substance are best suited to form and develop around the crystals, yet there is a very important distinction to be emphasized in connection with the general behavior of the colloidal substance to be best suited for the purpose of waterproofing. The hydrogel forming in Portland cement mortar is quite sensitive to the action of water and in some applications of Portland cement is objectionable, due to the expansion which occurs from abnormal development when brought into contact, such as immersion, with water. The colloid in an ideal integral waterproofing should accordingly be only slightly sensitive to the action of water. In contact with water it should expand and develop only to the extent that is necessary to thoroughly fill all unoccupied spaces and yield a density that will render the concrete impermeable. Any tendency for an overdevelopment of the colloid will result in manifesting an internal expansive force similar to that characteristic of the hydrogel itself which will develop internal strains tending to reduce the strength, with the possibility of their concentration in definite expansion cracks.

The colloid in an ideal integral waterproofing should also be one that will not show a tendency to lose its colloidal development when the concrete might for any period not be in contact with water but allowed to remain entirely dry. Under such conditions a truly colloidal integral waterproofing should substantially retain its colloidal development and not lose the water that is present in its composition, resulting in contraction and shrinkage that is slow in reverting to the colloidal state when again brought in contact with moisture. Colloidal materials, such as hydrated lime, aluminum hydroxide and clay, all of which have been used more or less but with limited results in integral waterproofing, are examples of substances which are very slow to revert to their colloidal state after having been thoroughly dried out.

Consistent with the present knowledge of the constitution and behavior of Portland cement, the product best suited to impart waterproofness to concrete is the colloidal substance which is limited in its sensitiveness to the action of water to develop just sufficiently to fill out the pores and interstices near the surface, so as to thoroughly exclude and prohibit the entrance of moisture, without an overdevelopment that would manifest internal strains. Such a compound obviously serves to protect the concrete against any abnormal change in its volume due to the internal colloid, by barring the absorption or entrance of the water into the actual interior of the mass, where it would come in contact and react in its characteristic way with the colloid naturally occurring in Portland cement.

In integral waterproofing the product of correct colloidal properties should best be introduced through the medium of the water, in order to insure the most even and uniform distribution. To accomplish this the product should be miscible with water, forming with very little agitation a colloidal suspension or solution. However, after it has been deposited with the greatest homogeneity throughout the entire mass of the concrete, in addition to colloidal development it should be characterized with more or less repellent properties, in order to serve not only in developing under the action of water so as to fill out any spaces left unoccupied by the evaporation of the water, but also to repel and reject water with which it may come in contact.

Lincoln Motor Co., Detroit, Mich. George D. Mason, Architect, A. A. Albrecht Co., Contractors, Walbridge Aldinger Co., Contractors
Truscon Waterproofing Paste, *Concentrated,* used in construction of this building.

CHAPTER FIVE

Influence of Water on Concrete

By Frank Burton, Department of Buildings, Detroit, Mich.

Influence of Wetting and Drying of Concrete on its Physical Properties—Colloidal Nature of Portland Cement—Experiments by Campbell & White on Expansion and Contraction of Concrete due to alternate Wetting and Drying—Similar experiments by Considerē—An interesting practical Example—Further observations by Professor White—Curves showing variation in Tensile Strength of Concrete on Wetting and Drying—Importance of Subject as related to entire Field of Concrete Construction—Theoretical Considerations—More Practical Examples.

Much has been written concerning the advisability and desirability of waterproofing concrete. In so far as the presence of water might prove a menace to health or property or be unsightly, the reason for waterproofing is obvious. In other cases, however, as for instance a concrete footing for a wall or column located below the cellar bottom, waterproofing is looked upon by many as superfluous. This is due to the fact that the effect of water upon the physical properties of concrete has either been considered too insignificant for consideration or assumed not to exist for the simple reason that water is one of the ingredients of concrete.

As a matter of fact, wetting and drying of concrete have a profound influence upon the physical properties of concrete and expecially upon its strength. Concrete being first of all a structural material, it seems proper that this subject should have received careful study long before this instead of being relegated to the realm of things too theoretical to interest the "practical" man.

So long as concrete was regarded as a mass of sand and stone tied together by a network of fine interwoven insoluble crystals, students of the subject could not be expected to anticipate the effect of wetting such a mass since insoluble crystals are hard and impervious and are not affected by water.

The weight of evidence at the present time seems to indicate that Portland cement is really a colloidal or jelly-like substance when set and that such crystals as do exist, being chiefly calcium hydroxide, are only incidental to the process of setting and do not constitute the real binding material. According to the most widely accepted theory at the present time, cement absorbs water much as glue absorbs cold water by swelling, but without dissolving. A chemical change then takes place which liberates part of the lime. This crystallizes out, leaving the mass harder and less affected by water than before, but still in a colloidal or plastic condition. As the mass dries this colloid shrinks slightly and slowly, but never loses its colloidal nature and upon being wet again, expands once more.

This phenomena has been observed by many experimentors, especially Professors Campbell and *White at the University of Michigan, who have carried out a series of very careful experiments extending over many years.

They found that dry neat cement would expand about .05 to .10% of its length when wet for a long period and would contract an equal amount when dried for a long period. Similarly concrete expands about .02 to .04% of its length on prolonged wetting and returns to its original length on drying.

The rate of this expansion and contraction is very slow. The larger portion takes place inside of three weeks, but the change in length continues at a slower rate for a long time.

Similar results have been obtained by other experiments, and Consideré, the French engineer, has reported even greater changes in length, as high as .15 to 2% for neat cement.

While a change in length of this magnitude is not great enough to appreciably distort the form of a concrete structure, the practical importance of taking account of even so small a change in length may be seen by examining the picture on page 23. This shows a building with brick bearing walls and reinforced concrete lintels over the first and second story windows.

After building the walls to the second story level, the wooden window sash was put in place and the top of the sash used as a bottom for the lintel form. The second story walls were then built and the upper lintel constructed in the same fashion. All was well until several weeks after the first lintel was poured and then the concrete being thoroughly dry, the top of the lintel contracted, while the bottom, being reinforced with steel, did not change in length. The result was that the lintel curled, the center going down, crushing and destroying the three mullions.

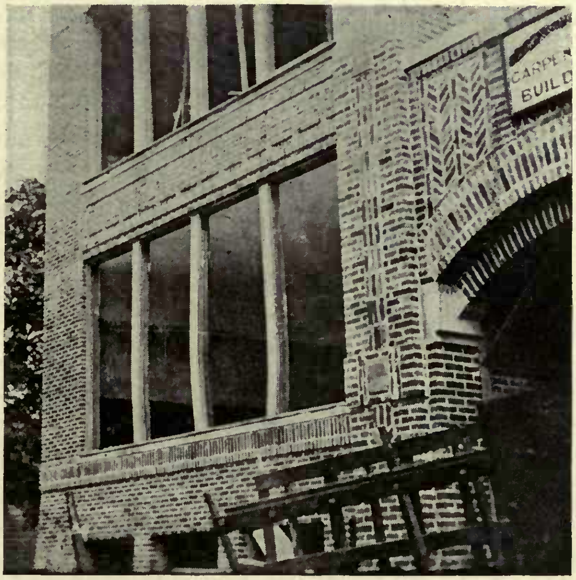
The result cannot be ascribed to any failure because the lintel was well designed and was

*Lieut.-Col. Alfred White, formerly Professor of Chemical Engineering, University of Michigan, has written an exhaustive treatise upon this subject entitled "Volume Changes in Concrete." This article was presented at a meeting of the International Engineering Congress, 1915, in San Francisco. It was printed in the Sept.-Oct. and Nov.-Dec. 1915 issues of Structural Conservation.

sound, hard and in perfect condition. Also it can not be due to the weight of the concrete because it did not appear until several weeks after the concrete was set hard. Moreover, if it had been due to the weight of the concrete or to settlement in the brick wall, the mullions on the second floor should have been similarly damaged, whereas they were perfectly straight. As it happened, the lower lintel curled down first and a few weeks later the upper littel bowed down an equal amount so that the second story lintels were not crushed.

When steel is imbedded in concrete this expansion and contraction introduces stresses of considerable magnitude both in the steel and in the concrete, but this subject is rather for the student of reinforced concrete than for one interested in waterproofing.

An interesting observation was made by Professor White at Ann Arbor. He found that a certain old cement sidewalk which laid perfectly flat when dry and even showed open cracks, would expand so much after a prolonged period of rain that the cracks would close and even force the walk to rise up in some places. By observing the temperature he proved that this was not due to thermal expansion.



It has often been a matter of speculation among users of concrete blocks as to why a long wall built of concrete blocks breaks into sections about 30 feet long, separated by more or less irregular vertical cracks, within from one to six months after being erected.

The reason is this. If the blocks are put up wet they contract and produce shrinkage cracks. If the blocks are dry then they expand during the first spell of wet weather, pushing the ends of the wall outward because the compressive strength of the concrete is large. Later when the wall dries out it contracts. If now the wall is short (less than 50 feet) it will draw itself together again. If, however, the wall is longer, the force necessary to draw the great weight of the wall along the ground will be too much for the weak tensile strength of the concrete and it breaks up into small sections.

Allied to the expansion of cement upon wetting is the property of concrete mentioned in the beginning of this chapter of losing a large portion of its strength upon being immersed in water for a day or two.

This property has long been observed, but is still little understood. It was recognized by the National Society of Cement Users in their Standard Specifications for cement blocks (Standard No. 3, Published 1909). This specification states that blocks shall be tested dry and also after wetting for 48 hours, and that all blocks should be rejected which lose over 33⅓% of their strength, unless the final test is over 1,000 pounds per square inch. A similar requirement may be found in the requirements of the New York Bureau of Buildings and in the building codes of Philadelphia, Cleveland and many other cities.

In the appendix of the report of the Bureau of Buildings of New York, Borough of Manhattan, 1911, are given twenty tests on concrete bricks. These tests were made by breaking the bricks in two and crushing one-half while dry and other half after being immersed in water. The result on the wet half block was less than that on the dry half block in every case. The loss varied from 19.3% to 36% and averaged 28%. Judging from the crushing strengths, all of these blocks were old and well seasoned.

In Engineering News, Jan. 16, 1913, there was published a letter referring to the difficulties encountered in laying concrete drain tile in the State of Iowa. The tile were a 1-3 concrete and were found by tests to be sufficiently strong to sustain the necessary earth pressure. In spite of this it was found that many of them crushed shortly after being covered up and becoming wet. The matter was taken up with the State University of Iowa where tests were made to determine the effect of wetting upon the strength of the tile. Preliminary experiments showed that the tile lost from 40% to 50% of its strength shortly after wetting. These results are rather high but may be due to the fact that the concrete used in drain tile is made of cement and sand only, large stones not being admissible in these products.

Faber and Bowie in their book on Reinforced Concrete give two curves showing the variation in tensile strength of concrete upon wetting and drying. These curves show that concrete upon wetting decreases rapidly in strength and then after prolonged wetting slowly regains its strength. If after prolonged immersion in water the sample is taken out and dried, another considerable decrease in strength is observed, but after prolonged drying the strength gradually returns.

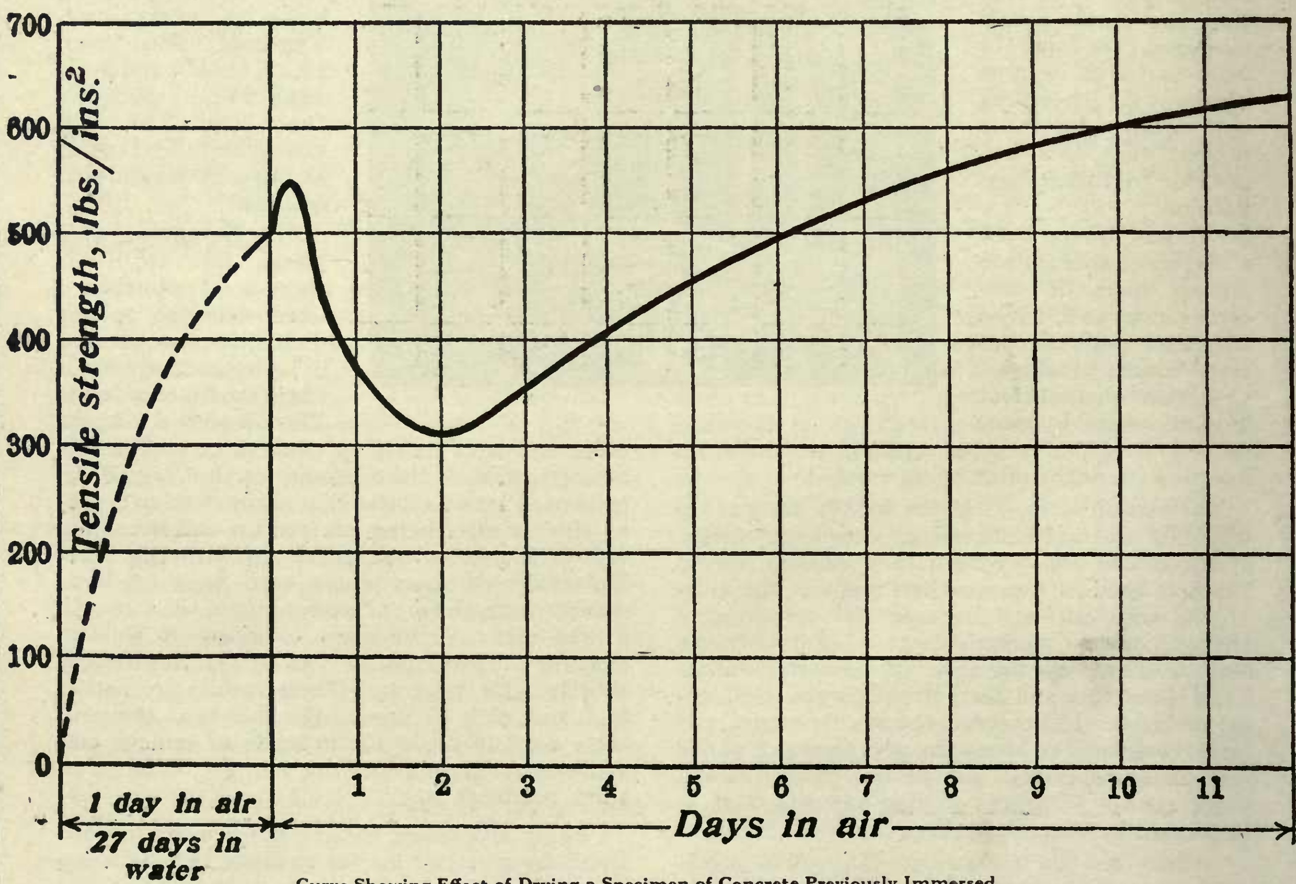
In each case the rate of recovery of strength is very similar to the increase of strength of green concrete upon being aged. The increase starts shortly after becoming completely saturated with water. The rate of increase is rapid at first, decreasing with time so that after a few weeks it is practically negligible.

Viewed in this light the wetting and drying of concrete becomes exceedingly important, structurally. It means that we must use a factor of safety nearly twice as large as is required for other materials or risk failure. Obviously the moral is to prevent the wetting and drying, that is, to prevent rapid changes in the moisture content of all structural concrete. In other words structural concrete exposed to the action of water should always be waterproofed.

Before closing this chapter, I wish to take up one question that has undoubtedly occurred in the mind of the reader, that is: just what connection is there between the expansion of cement on wetting and the loss of strength of concrete when wet. An adequate discussion of the matter is not possible here and the author does not pretend to understand just what the mechanism of the phenomena is, still there is good reason to believe that it comes about somewhat as follows:

Concrete is composed of hard particles of sand, stone, etc., which are impervious and are not affected by water. Between these particles are layers of pure cement which expand appreciably when saturated with water. If we consider one grain of sand with a small amount of pure cement adhering firmly to one side, we see that the cement must be compressed and the sand stretched, otherwise the two could not remain together. This creates a shearing force along the plane separating the particles. From this we can see that the mass of concrete would become filled with innumerable small shearing forces of considerable magnitude, in other words the mass would be under great internal strain.

Internal strains always weaken a mass and this undoubtedly accounts for the decrease in



Curve Showing Effect of Drying a Specimen of Concrete Previously Immersed.
Faber & Bowie

strength. Drying the mass causes a shortening of the cement particles and therefore produces a similar result, as this also produces internal strain.

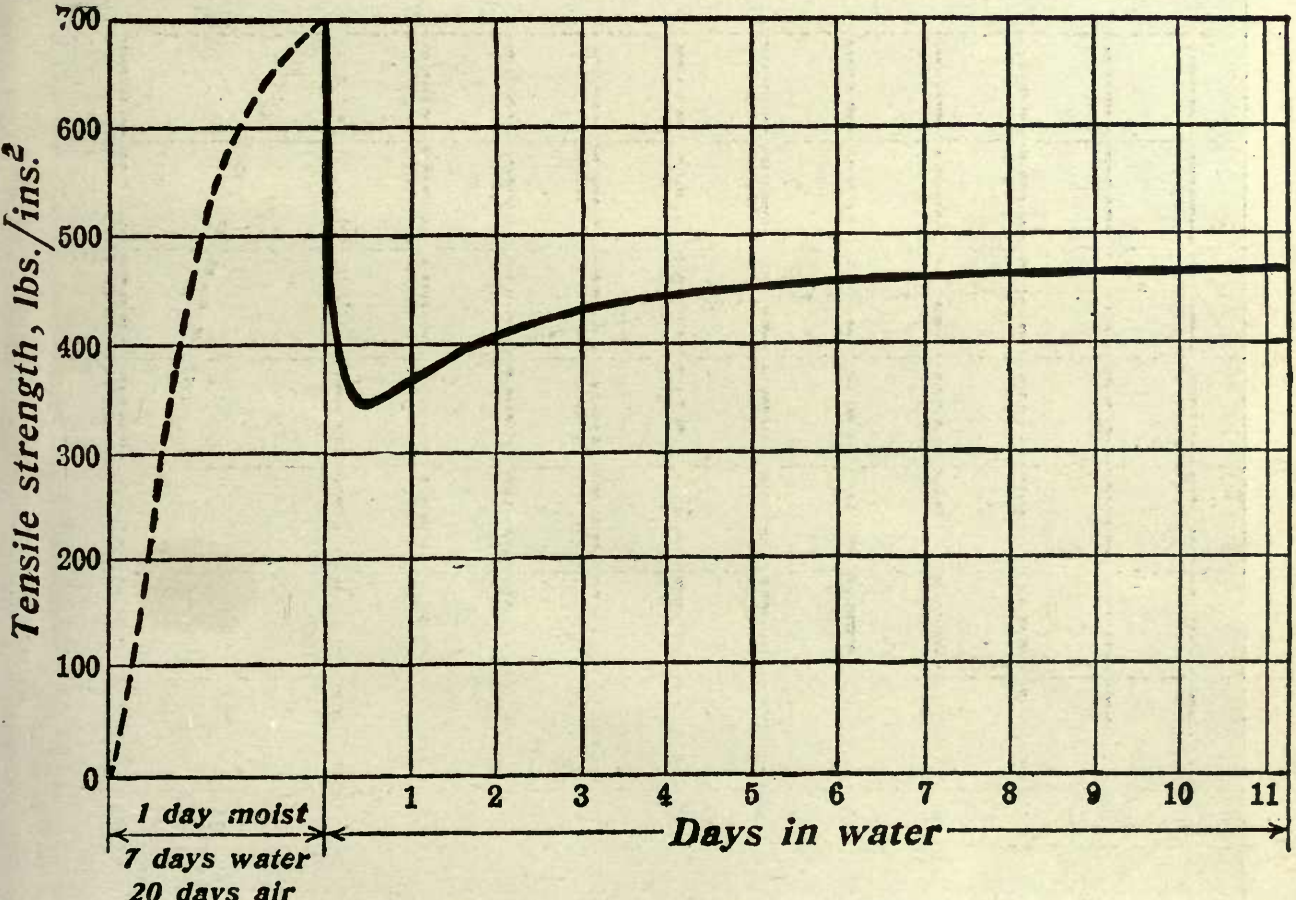
As was said before, set Portland cement is a plastic colloidal substance. Now all plastic bodies under strain are gradually distorted so as to release the strain. In just this way the cement portion of concrete gradually becomes distorted, stretched or shortened as the case may require, until the internal strains are released, allowing the mass to approach the strength it would have if entirely free from internal strain. This probably accounts for the gradual increase in strength of concrete either when first aged or when subject to alternate wetting and drying.

In spite of the vast amount of experimenting that has been done upon the properties of concrete, the effect of alternate wetting and drying is a subject which has scarcely been touched. Enough is known, however, to teach us that it is a matter to be reckoned with and that rapid changes in the moisture content of concrete must be avoided where structural economy is a consideration.

The illustrations on the next page show very interestingly the result of alternate wetting and drying discussed in this chapter. They give added testimony to the results which will occur when the conditions for the expansion resulting from alternate wetting and drying are not favorable to allow this change to take place.

The curb shown in Figure 3 was erected in connection with a reinforced concrete pavement. The necessary provisions for expansion were not made and after a term of a few months, the curb became internally heavily compressed, due to the strain of the increased volume which ultimately manifested itself in the rupture as shown.

A curb of a concrete pavement is obviously a very representative installation of concrete that would likely be subject to the alternate conditions of wetting and drying. The pavement poured to crown naturally drains the water toward the curb, which holds it as it is



Curve Showing Effect of Immersing a Specimen of Concrete Previously Dry.
Faber & Bowie.

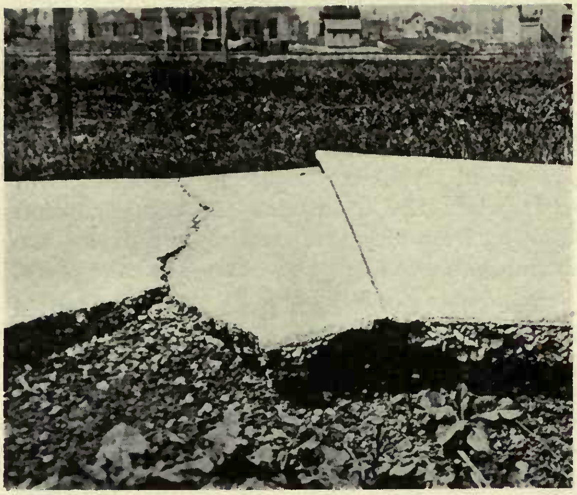


Figure No. 1

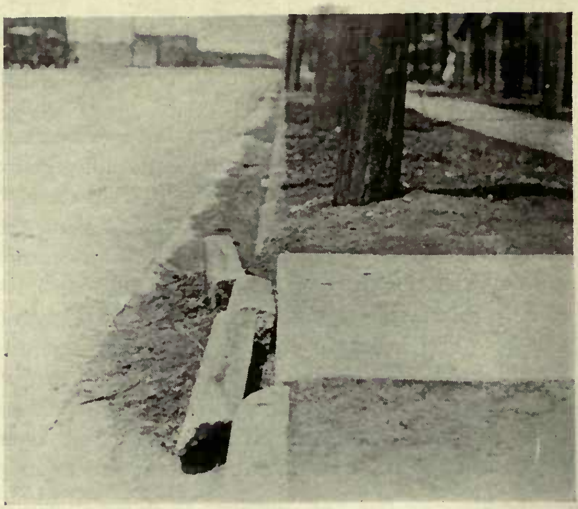


Figure No. 2

Figure No. 3

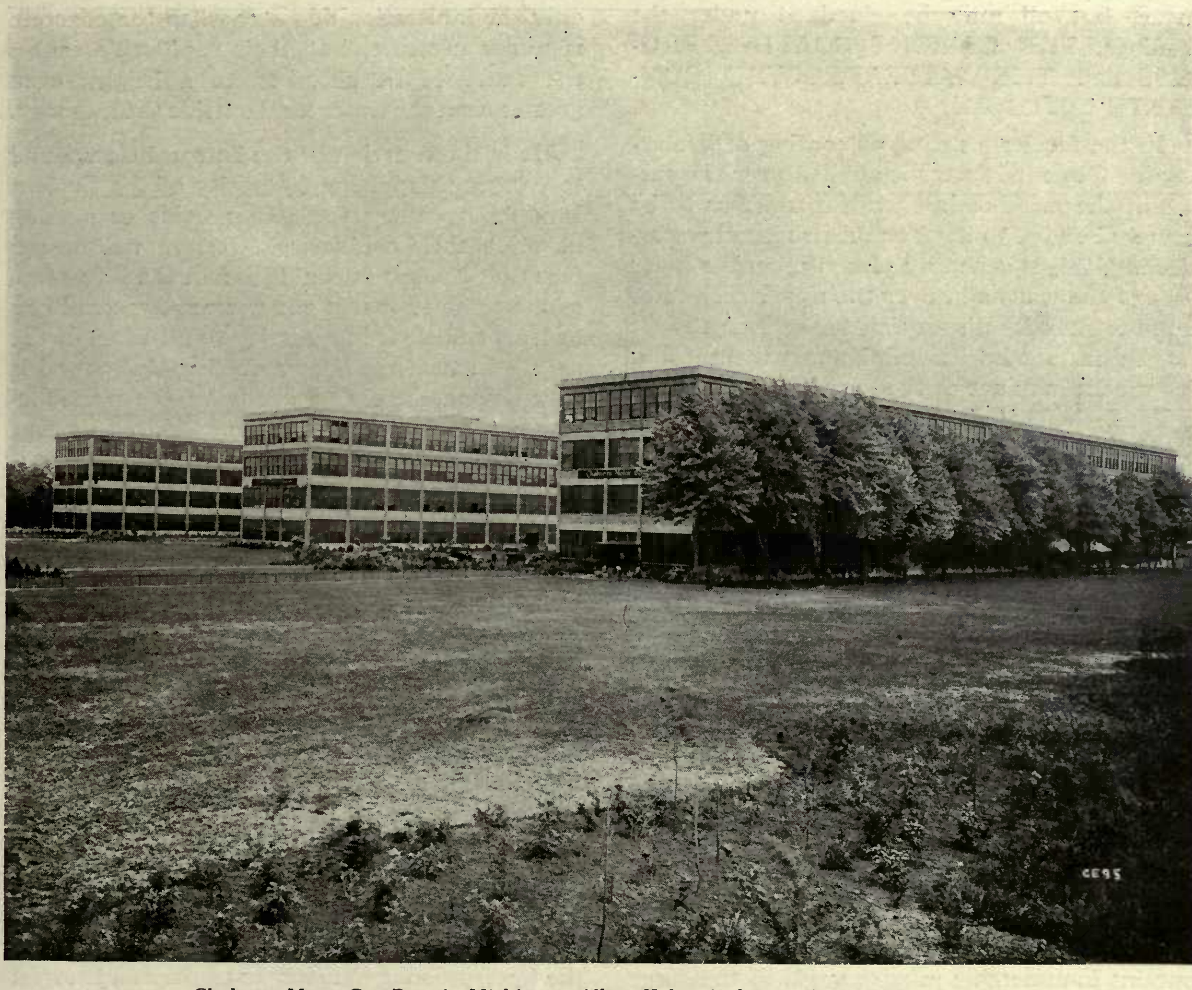
being carried to the sewage outlet. This gives opportunity for considerable free contact of the concrete with the flowing water to permit its absorption and penetration into the concrete mass so as to thoroughly expand the colloid and cause the natural increase in volume accompanied by the wetting or saturation of the concrete mass.

After the water has drained out, the curb with its fairly large percentage of exposed surface, permits quite free evaporation of the water and the resultant contraction in the concrete as it dries out. This alternate saturation and subsequent drying has caused to accumulate a slow, additive increase in volume with the result as illustrated.

This is but an added illustration of cases where the concrete should be thoroughly waterproofed so as to avoid the free penetration of moisture. If this curb had been constructed of concrete that was thoroughly waterproofed so as to avoid any absorption or penetration of moisture, it would have remained in constant volume, and it would have been protected against destruction.

It is cases of this character that are bringing to the attention of architects and engineers the necessity of using greater care and caution in concrete that is exposed particularly to weather conditions.

While the difficulty may not be so important in concrete that is enclosed and is protected from alternate wetting and drying, yet for all character of construction where there is opportunity for occasional wetting and subsequent drying or for alternate conditions of this character taking place, the concrete should, in addition to careful proportioning and the exercising of considerable care in placing, be thoroughly waterproofed so as to prevent the changes in volume that invariably occur where the entrance of the water is not prohibited.



Chalmers Motor Co., Detroit, Michigan. Albert Kahn, Architect, Ernest Wilby, Associate

Truscon Waterproofing Paste *Concentrated*, used in concrete work.

CHAPTER SIX

Integral Waterproofing with Particular Reference to the Mass Method

By A. D. Hyman, Waterproofing Engineer, New York City

The Function of Waterproofing Compounds—What Waterproofing cannot do—Composition of Concrete—Proper Proportioning—Amount of Gauging Water—Correct Proportioning of Waterproofing Compounds—Cautions on Concreting Work—Importance of Proper Bond in Construction Joints—How to provide proper Bond—Necessity of Removing Water Pressure during Construction—How this can be done—Six Important Considerations in Waterproofing.

That method of Masonry Waterproofing whereby a chemical compound is diffused throughout a hydraulic cement product is popularly known as the Integral Method. Variations of this general method appearing under trade names or terms descriptive of the operations involved or the products employed are in vogue, but all may be classified under the headings, THE CEMENT COATING PROCESS and THE WATERPROOFED CONCRETE METHOD.

In the former a facing or coating of Waterproofed Cement Mortar is applied over the surface of the member in such a manner as to be securely bonded to it. For substructural waterproofing, this is generally placed upon the inner faces of the walls and over the upper surface of the floor-slab, its disposition being such that it can be installed with minimum expense, and also that it may act as the floor wearing surface and wall plaster finish. It is proposed herein to deal particularly with the WATERPROOFED CONCRETE METHOD in which the Integral Compound is diffused throughout and becomes an integral part of the mass concrete.

In order to have a full comprehension of the considerations, which enter into the successful application of this method of waterproofing, one must first have a knowledge as to the part the waterproofing compound itself is called upon to play. The whole system of Integral Waterproofing has been condemned in numerous instances because of the lack of understanding as to its exact function.

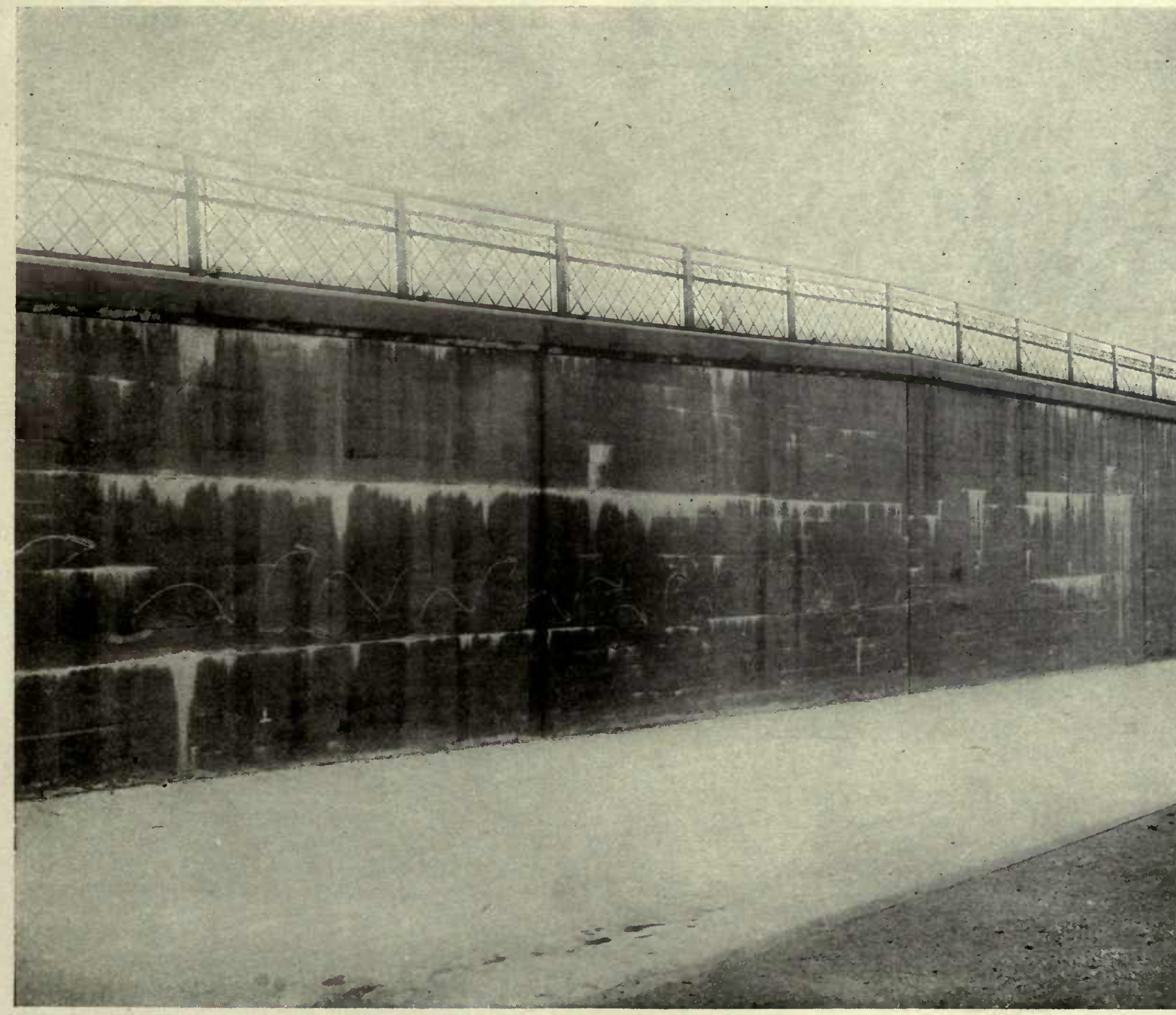
Without entering into the technique of the setting of cement, the attention is directed to that noteworthy feature of concrete, that even though of perfect proportioning and mixing, it contains innumerable minute voids in the form of hollows and ducts or channels, left by the inability of the particles to properly arrange themselves to secure an absolutely dense mass, and also by the evaporation of the excess of the gauging or tempering water. The larger of these pores can be seen with the naked eye, but the microscope reveals the actual porosity of any concrete specimen. These voids allow not only the infiltration of water when the concrete is under pressure, but their capillarity causes the water to be absorbed to a height, even greater than the water level outside the masonry.

It is the function of the Integral Compound to correct this inherent porosity of the Cement Product by filling these tiny voids or making negative their capillarity. It is a well-known fact that the sand should just fill the interstices of the stone or gravel and the cement should be at least sufficient in quantity to fill those of the sand. In turn the Waterproofing Compound is called upon merely to act upon the pores between the particles of the crystallized cement and sand and those within the cement content itself. *It is not capable, however, of remedying any defects of construction or design, nor to correct improper and defective materials and workmanship.* The cement, sand and aggregate must fully perform their respective functions and this will obtain only in first class masonry. Abuse and condemnation have been heaped upon Integral Compounds where the fault lies entirely with the concrete work, and until the fundamental function of these compounds is universally appreciated as well as the necessity for fulfilling the conditions for obtaining good concrete, the real merit of Integral Waterproofing will not be fully asserted. Unless the masonry be first class in every respect it is a useless expenditure, and a detriment to the waterproofing industry to employ an Integral Material.

Dwelling briefly upon the essentials for good concrete, first, only proper materials should be used. Good cement costs no more ordinarily than cements of poor quality, so this important component is generally all that is to be desired. As for the sand and gravel content, however, there is much room for comment. Particularly in outlying districts where the importation of these materials is an item of considerable expense, the importance of good, coarse, clean sand and gravel is often minimized and local materials used when they are entirely unfit. "Run of the bank" aggregate is often employed although there is almost invariably a large excess in sand, and to fill the sand voids and thus secure concrete of normal structural strength, it is necessary to incorporate an abnormally large quantity of cement. Besides the surplus of fine particles, "bank run" material usually contains a large percentage of loam, clay and other foreign materials deleterious to good concrete.

The proper proportioning and adequate mixing of the ingredients are of quite equal importance to their quality, all of which is obvious but often neglected. A lean mixture of concrete may be far superior to a rich one if the mixing of the ingredients be more thorough.

The amount of gauging water is also to be considered, and for best results as to density and also for strength, a mass of quaking consistency should be obtained. In field work, it is of course impossible to so regulate the water. that all batches will be of like consistency and indeed this is not necessary. However, it should be borne in mind that mixtures too dry are porous as the particles fail to compact themselves from lack of lubrication, while the extremely wet mixtures are porous from the hollows left by the evaporation of the large excess of gauging water. It should, therefore, be the constant endeavor in Waterproofed Concrete work, to so regulate the water supply that



No. 1 Section of Retaining Wall showing leakage of construction joints, a common defect of ordinary concrete work.

the mass be as near "quaking consistency" as possible. For cement floor work, to secure maximum density and hardness the consistency should be such that a pailful of mortar will just retain its form when upended and pail removed. Concrete, however, should be deposited somewhat wetter than this.

The correct proportioning and thorough diffusion of the Waterproofing Compound also

View No. 2
One Outlet for Water Removed from Foundation of Riverside Station, Elmira, N. Y., During Process of Construction

demands attention. Since the duty of this material relates to the cement voids the quantity to be used is a direct function of the cement content in the mortar or concrete. This statement appears paradoxical since theoretically more Waterproofing would be required for a lean mixture than for a rich one. However, the matter is clarified when it is remembered that the concrete itself must be of dense nature, the cement matrix being sufficient in quantity to completely fill the stone or gravel voids. Only the richer mixtures should be used, and for concrete subjected to hydrostatic pressure this should not be appreciably leaner than 1:2:4.

For maximum efficiency Waterproofing Compound should be added in quantity up to that point where a further increment would have a weakening effect upon the strength of the cement. The quantities advocated by the manufacturers of the materials are generally considerably less than the allowable maximum for economy's sake and to allow an ample margin of safety, and it is advisable always to follow their directions in this regard. There is a general tendency to increase the quantity of the compound in the members subjected to the greatest pressure, but this is to be discouraged unless it be authoritatively ascertained that the allowable quantity limit is not thereby exceeded. Special care should be observed in the complete diffusion of the Compound throughout the mass as this is manifestly of equal importance to its correct proportioning. An excess of Waterproofing material in one section and a deficiency in another is of course a highly undesirable condition.

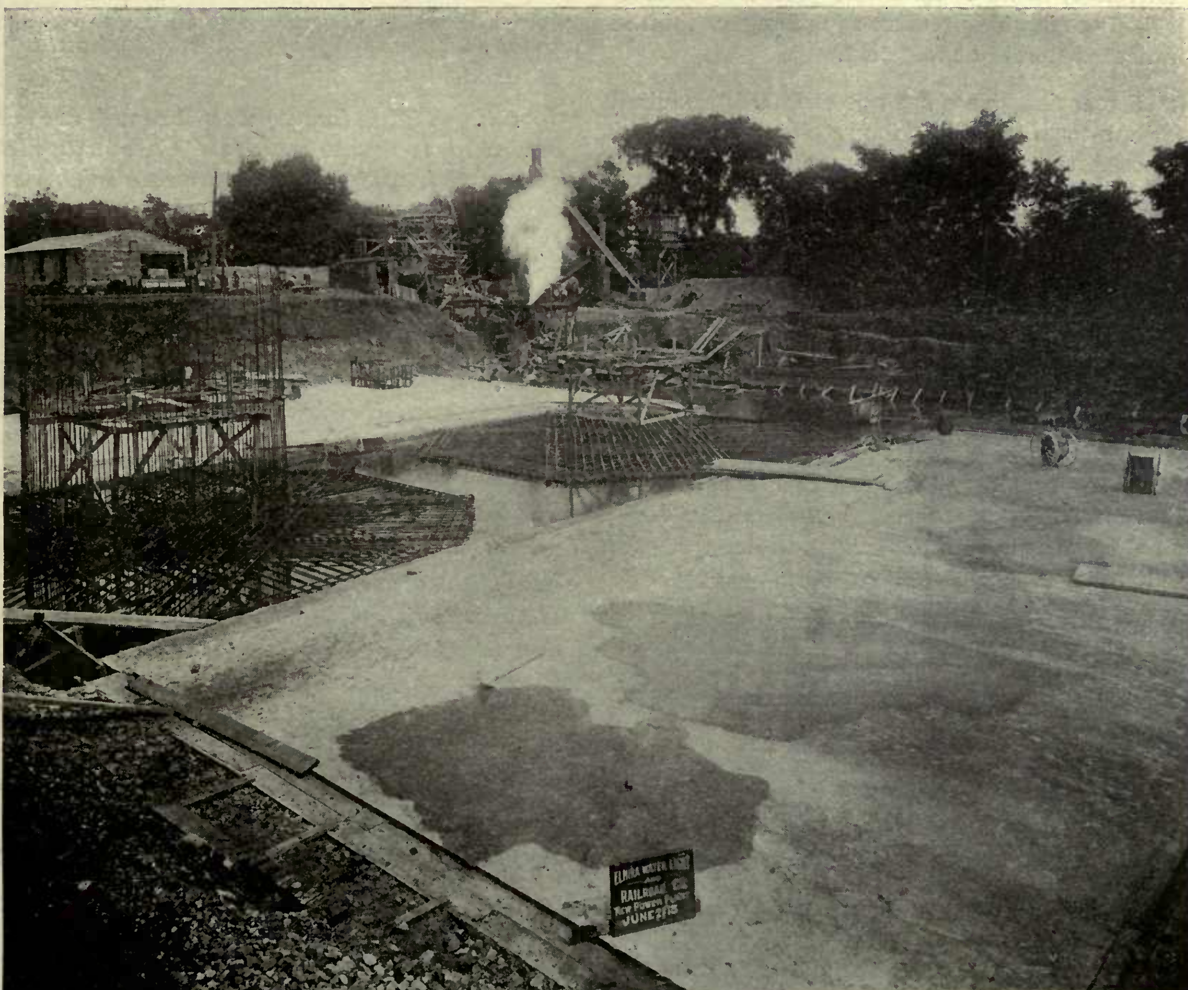
It is often maintained that if proper care be taken in the proportioning, mixing and placing of the ingredients, impervious concrete can be obtained without resorting to Integral Compounds, and indeed laboratory tests substantiate this assertion. However, in field operations where ideal conditions do not prevail, even the best concrete will allow the infiltration of water through portions at least, and comparative sections of concrete with and without a standard Integral Waterproofing Agent, will prove the fallacy of the assumption under working conditions.

The concrete should be carefully deposited in the forms—never dropped from a sufficient height to separate the ingredients. The mass should be well spaded, particularly those portions at the faces, so as to avoid honeycombing. *All wooden spreaders and in fact wood of every description should be removed from the plastic mass.* Not only is wood decidedly pervious but its swelling and subsequent warping if it come into contact with water, will cause internal stresses which may prove serious. All bolts and wire fastenings should be cut off at least an inch from the face of the concrete and the resultant holes pointed up.

Tight forms well braced are a prime requisite, as the cement water which is allowed to escape from loosely constructed and inadequately braced forms, contains the richest part of the strength-giving matrix.

A most important factor for Waterproofed Concrete and one perhaps most often neglected is the securing of a proper bond at the construction joints, vertically and horizontally, for unless due precautions be observed, these will develop planes of weakness. View No. 1 illustrates a section of retaining wall of a bridge approach of a prominent western railroad. The seepage at the joints between the different days' work is a salient feature of the work, but indeed this fault is so general in ordinary concrete work of this nature that it creates but little attention. However in Waterproofed Concrete Work such faults must not exist for obvious reasons. At horizontal joints, laitance consisting of inert particles of cement and an excess of Waterproofing Compound collecting at the surface of concrete, must be removed and the surface scarified before new material is deposited upon it. The importance of this measure cannot be overestimated and yet its extreme necessity is rarely appreciated. After the removal of the bulkheads the vertical surfaces should be thoroughly roughened (except in the case of expansion joints) preparatory to depositing the concrete in the adjoining section. For small structures or portions subjected to great pressure as pits, etc., the concrete work should be carried continuously to eliminate construction joints.

A consideration to which many failures in Waterproofed Concrete may be attributed is that relating to water-pressure existing during construction. An axiom for successful Integral Waterproofing is that "*Ground water, whether running or confined, must be kept away from the mass until final set has been attained.*" If water under pressure be allowed to percolate through the plastic concrete, channels are formed and its efficiency as a Waterproofing Medium is destroyed. This principle is of great importance and to ignore it is to court trouble and inevitable failure. Ordinary concrete can be deposited under water often with very good results but not so with Waterproofed Concrete or Mortar. Water should not be permitted to come into contact with any part of the cement product until it is fully capable of resisting the pressure, and draining and pumping or bailing must be resorted to when necessary to fulfill this requirement. View No. 2 indicates the large quantity of water removed during the progress of construction of the Riverside Station at Elmira, N. Y. Two wooden stave pipes as outlets for the steam and electric pumps which operated continuously during the critical stages of construction, discharged upwards of 10,000,000 gallons of water per day.



View No. 3. Indicating method of controlling water during construction work. Note the wooden box drain at cutside of concrete floor slab·

When the quantity of ground water is considerable, the earth slope should be kept sufficiently outside the neat line of wall to permit the construction of a box or tile drain, (shown in View No. 3) or an open ditch at the level of lowest portion of Waterproofed masonry so that the water may be lead to a sump-pit thus relieving the pressure from the walls. Before the construction of the floor-slab a layer of gravel, broken stone or cinders 3 inches to 6 inches in thickness should be deposited for the dual purpose of allowing free access of the water to the sump-pit during the progress of work and for equalizing the pressure after the structure is completed. Sub-floor drains should be constructed, if necessary. In the case of heavy clay, or other impervious soils it not infrequently happens if the concrete be placed directly upon the earth that the pressure over one portion will be considerable while over another it may be nil. Therefore, in all cases where pressure exists or is likely to exist, a pressure equalizing medium as indicated should be installed.

Expansion joints are not ordinarily required for sub-terra work but for retaining walls, etc., exposed to extreme temperatures, they are a necessity. Copper flashing embedded in the adjoining sections of the masonry at the exterior face has been found very effective in rendering joints watertight, while a bituminous or rubber mastic spread by trowel over the vertical sections of concrete after the removal of the transverse bulkheads is very efficient in permitting the required expansion and contraction of the concrete.

Every section of a substructure should be carefully designed so that it will possess sufficient strength to resist all possible pressures and its foundation such as to preclude settlement. The Waterproofing can remain effective only so long as the bases remain in a sound and stable condition, and that this may obtain the substructure must act as a caisson in resisting the hydrostatic pressure while the structure itself must be able by weight to counteract the upward lifting force. The function of the Waterproofing is of course only to make the members impervious and not in any way to provide structural strength. This fact is often lost sight of, however, and futile attempts are not infrequently made to waterproof members not able to resist the pressure. A rupture in the wall or floor-slab is the result, and when such occurs only too often is the fault laid at the door of the Waterproofing System.

Briefly reviewing our discussion, the important considerations for the successful construction of Waterproofed Concrete may be summed up as follows:

1st. The ingredients for the concrete must be standard in every respect; the sand must be clean and coarse and the gravel or broken stone of best quality.

2nd. The integral Compound must be of tested merit, incorporated in accordance with the manufacturer's directions and thoroughly diffused throughout the mass.

3rd. The ingredients must be so proportioned that the cement will completely fill the voids (if the sand and the matrix enter into all voids) of the aggregate. The mixing must be thorough so that all parts will be of uniform density, and a mass of "quaking consistency" should be secured.

4th. Tight forms well braced are an essential to good results. Care must be assumed in placing the concrete with particular attention to the spading at the faces and to the horizontal joints between the different days' work. No wood of whatsoever character should be allowed to to remain in the concrete.

5th. Ground water must be kept from the mass until it is capable of resisting the destructive action of the water. Drainage and pumping must be resorted to when necessary.

6th. Each member of the structure must be so designed and constructed that the water pressure will be resisted without exceeding its structural strength. The foundation must be able to support the structure without excessive settlement, and the structure as a whole must possess sufficient weight to counter-act the lifting pressure.

If these fundamental conditions be fulfilled, good results are assured. Every unsuccessful case of Integral Waterproofing in the past may be attributed to the lack of regard of one or more of these, while with their careful observance failure is impossible.

CHAPTER SEVEN

Waterproofing Stucco

Why Waterproofing for Stucco is Necessary—Penetration of Moisture into Pores of Stucco—Effect on Stucco of Freezing of this Moisture—How Waterproofing relieves this condition—Porosity of Stucco as demonstrated by Test—Circumstances of Test—Practical Illustrations of Unwaterproofed Stucco.

When properly formulated, stucco constitutes one of the most ideal building materials. Rapidity of construction, economy of labor and material, and fireproofness characterize its use. The aggregate necessary for the stucco is available in every locality and obviates the necessity of transporting materials from one place to another. In addition to these valuable qualities, stucco is exceedingly durable and lends itself admirably to artistic effects.

Stucco, however, to fulfil the valuable applications to which it can be applied, must first and foremost be absolutely waterproof. Without this quality, its real value is in a measure destroyed. This can be easily comprehended when the nature of stucco is understood.

In the mixing of cement stucco, the amount of water used is largely in excess of that required for chemical hardening and setting. The water, being incompressible, occupies a definite volume. Upon evaporation of this excess water, the space which it formerly occupied is left empty in the form of capillary pores. These pores, unless preventive measures be taken, allow for penetration of moisture which results in cracking, disintegration, and discoloration.

Prof. White* has shown that the expansion and contraction of concrete due to temperature is comparatively insignificant in comparison to the volume changes due to alternate wetting and drying. Portland Cement mortar or concrete shows a marked tendency to increase in volume when wet and to contract when dry. This action is characterized by the interesting fact that the contraction which occurs on the drying out of the mortar or concrete after the expansion from wetting, is less in its negative value than the positive increase in volume which occurs from the wetting. This naturally results in a slow additive increase in volume developing from alternate wetting and drying which ultimately develops an internal strain that will be evidenced by the formation of cracks in the stucco. Naturally as soon as the cracking occurs, opportunity is offered for the deeper penetration and concentration of moisture which will hasten the disintegration of the stucco.

This penetration of moisture has a further disintegrating effect. The moisture freezes in winter, and upon so doing, expands 9% of its volume. The tremendous disruptive force thus produced makes it easy to understand why unwaterproofed stucco will have an untimely end.

The illustrations 2 and 3, on the following pages, demonstrate the failure of stucco which has not been waterproofed. In Illustration 2, the scaling off of large sections is primarily caused by water penetrating through the cracks which have formed, and on collecting back of the stucco

*See foot note—Chapter Five

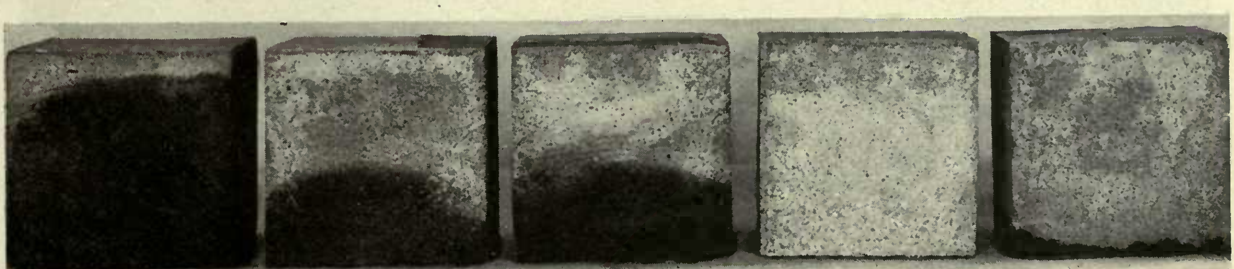


Illustration No. 1

Plain Imperfectly Waterproofed Effectively Waterproofed and expanding when freezing, thrusting the stucco away from the surface. Illustration 3 shows the result of the additive increase in volume due to alternate wetting and drying which have created the internal strains which in turn have expressed themselves in definite cracks.

With waterproofed stucco, there is no opportunity for the absorption or saturation of the stucco with water. It remains in practically constant volume subject only to the slight changes in volume due to variation in temperature conditions.

As a simple test to physically demonstrate the natural absorbent nature of untreated Portland cement stucco as compared with waterproofed mixtures, a series of 4″ cubes were prepared composed of one (1) part of cement to two and a half (2½) parts of sand by volume. A number of these cubes were made without waterproofing treatment in order that the full absorbent nature of the untreated specimens could be observed in comparison to other cubes which were prepared with the addition of various integral waterproofings.

These cubes were allowed to cure for seven days in a moist closet, and after a subsequent exposure of twenty-one days in the air, were subjected to observations to determine their absorbent qualities. A bed of sand of a depth of about three inches was prepared in large sheet metal pans which were filled with water so as to thoroughly saturate the sand. Over the surface of the dampened sand was placed a layer of thin cloth which immediately became

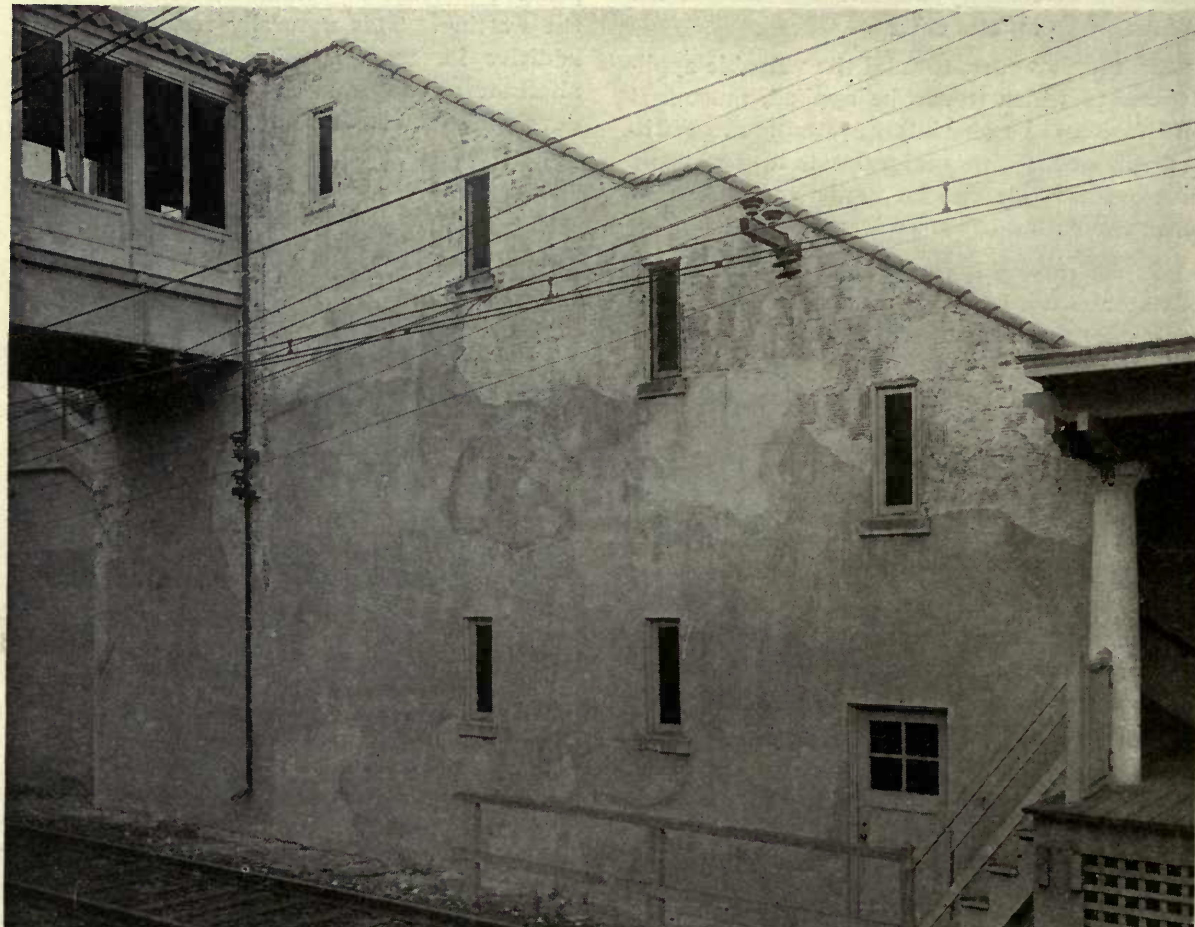


Illustration No. 2

Scaling off of stucco due to water penetrating pores and cracks. On collecting back of stucco and expanding when freezing this water exerts a tremendous disruptive force which causes the condition indicated in this photograph.

Illustration No. 3

The additive increase in volume due to alternate wetting and drying of stucco creates internal strains which express themselves in cracks. This illustrates an example of what is liable to befall stucco unless properly waterproofed.

fairly wet and saturated from the excess of moisture in the pans of wet sand. The blocks to be tested for their absorbent qualities were placed on the cloth resting on the dampened sand.

The conditions of this test were designed to provide plenty of moisture in contact with the mass of the block under normal pressure to observe the exact rate and extent of the penetration of the moisture in the block due to natural absorption.

Illustration 1 shows the extent to which the moisture had been absorbed into a plain block after a period of about seven days, during which time the sand was kept thoroughly saturated by the regular addition of water. The illustration also shows two blocks in which waterproofing treatments were only partially effective, and while the absorption is not as much as with a plain block, yet it is insufficient to properly protect the stucco against the natural disintegrating action of the water.

In contrast to the plain block, the illustration also shows the two blocks which were perfectly waterproofed and in which there was practically no absorption after a period of seven days in contact with a moist saturated sand.

Taking into consideration the laboratory tests and the actual demonstrations furnished by stucco buildings, there is little to be argued against the practice of waterproofing all stucco construction. With the presence of waterproofing, instead of the stucco becoming continually wet and saturated, in which condition it is subject to slow decay and disintegration, the stucco is made absolutely impermeable and non-absorbent. The moisture is absolutely excluded from entrance and confined to simply superficial contact. The stucco is made crack-proof and permanent.

Waterproofing stucco is a very simple and inexpensive matter. A very small amount of waterproofing material is required and this is added simply and directly to the water used in mixing the concrete mortar. Directions for waterproofing stucco are on page 70.

CHAPTER EIGHT

Integral Waterproofing by the Cement Coating Process

By A. D. Hyman,

Chief Engineer of the Waterproofing & Construction Co., New York City

Introductory Discussion—The Cement Coating Process—Preliminary Steps—Preparation of Surface for Bond—Preparation of Plaster Coat—Plaster Coat Ingredients and their Properties—Thickness of Coat for Walls and Floor—Necessity of Continuity of Plaster Coat—Necessity of Insulating Waterproofing under Abnormal Conditions—Construction Joints between different day's work—How to Eliminate Weaknesses from appearing—Bleeding Walls to Remove Pressure—Construction of Drainage System to eliminate pressure—Concluding Comments.

The term "INTEGRAL WATERPROOFING" is authoritatively intended to include any method whereby a chemical compound is introduced into a hydraulic cement product with the view of creating impermeability.

This general type of waterproofing is subdivided into two separate and distinct methods, each of which possesses characteristics that afford it individual merit and advantages. That method whereby a Waterproof Cement Facing or Coating is applied over the surface of the members is termed the CEMENT COATING PROCESS, while that method in which the waterproofing material is incorporated throughout the mass concrete of the structural members is characterized as the WATERPROOFED CONCRETE METHOD.*

The manner by which the Waterproofing Compound is introduced into the mortar or concrete varies with the nature of the product. Waterproofing Powders are usually mixed with the cement either at the mill, or by hand just before use upon the job. Liquid compounds are generally diluted with water and poured upon the dry mixture of sand and cement or charged directly into the concrete mixer, while pastes are diffused throughout the tempering water. Manufacturers' directions for each individual material should be rigidly adhered to in all cases. It is of the greatest importance that the recommended quantity be incorporated, and it is manifestly of equal importance that the material be uniformly distributed throughout the mass.

*The writer assumes responsibility for coining these expressions descriptive of the two general methods, and as hitherto a great deal of confusion has existed in the construction of the term "Integral Waterproofing," as to which of the methods is referred to, he trusts that these expressions will come into standard usage.

For maximum efficiency the greatest amount of waterproofing material should be utilized without impairing the strength of the cement. Since, however, an excessive amount does tend to cause a decrease in the setting values, such excess should not be present in any portion of the final cement product.

The inference deducted by the layman who has but casually investigated the subject, that the more material used the greater the efficiency, is vitally in error in INTEGRAL WATERPROOFING. The writer has in mind an instance of a superintendent "wisely" instructing his foreman to use the Waterproofing "double strength" for a certain piece of work where the pressure was unusually great, and another where a Waterproofing Powder Compound was used in its undiluted state by throwing it against the surface in attempts to remedy a leaky pit. Such cases appear absurd to anyone familiar with the subject, but Waterproofing Compounds are maltreated and misused perhaps to a greater extent than any other building commodity, this being due largely to the lack of appreciation that Masonry Waterproofing presents a truly scientific proposition.

INTEGRAL WATERPROOFING when intelligently executed is perhaps the most efficacious of all the systems in vogue, and the fact that it has been condemned in innumerable instances is due entirely to incorrect usage, improper application and the lack of comprehension in its exact function.

Of the two methods under discussion, the CEMENT COATING PROCESS especially requires the utmost diligence to secure the desired result. In fact, this work should preferably be undertaken by a specialist in this particular line, as the necessary observances and the precautionary measures are of such importance that the average contractor is not fully qualified for the successful performance of the work.

Before applying the Waterproofed Coating the surfaces must be especially prepared that a suitable bond be obtained. In fact, this preparation of surface is most important and many of the past failures in the application of the Process may be attributed to the lack of care in this operation.

The proper bonding face is obtained by thoroughly roughening, cleaning and grouting the surface. The Wall or Floor Slab must be saturated with clean water to destroy excessive capillarity, for otherwise the pores of the masonry will absorb a large percentage of the gauging water together with the finer particles of cement, and the strength and efficiency of the Coating be impaired. Particularly in the case of brick walls or floors should the members be thoroughly wet down owing to the great absorptive property of this material. A slight amount of absorption is desired, however, as it assists materially in obtaining the necessary bond.

In the case of concrete walls the entire face is chipped to expose the aggregate, while for brick and rubble the joints are raked and the surfaces roughened. For floors it is highly advantageous to apply the Waterproof Coating the day following the placement of the concrete slab in order to simplify the bonding operation. When the Coating is applied over old concrete floors similar precautions as for walls must be observed.

THE CEMENT COATING is prepared by an intimate mixture of Portland Cement and coarse sand with the incorporation of an Integral Waterproofing Compound. Proportions of one part cement to two parts sand are best

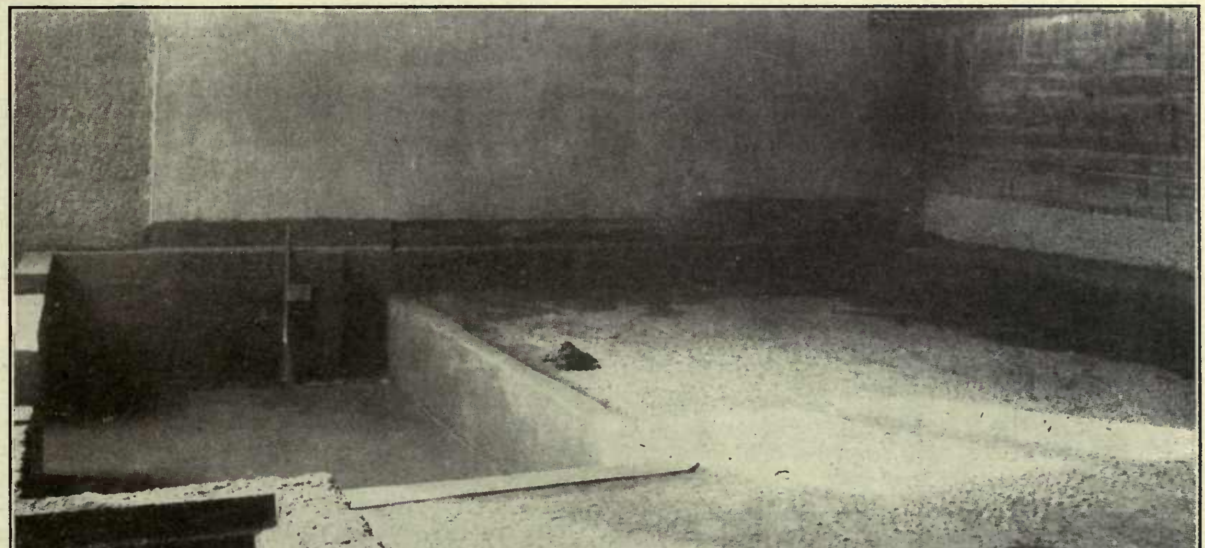


Plate No. 1

Typical view showing waterproofing work in progress. Site of future Boilers of Ward Bakery Co., East Orange, N. J. Pit at the left for fire boxes of boilers; floor grade at elevation of top of wall in foreground allowing the entire area under boiler depressed to allow for insulating coat. Complete substructure of this building waterproofed by the Cement Coating Process.

adaptable for the purpose, as mixtures considerably leaner than this are too porous, whereas Coatings of richer mixture have a tendency to crack under temperature changes.

For waterproofing vertical surfaces the Coating is applied in two coats, scratch and finish, giving a total thickness of ¾″ to 1″, while for horizontal surfaces the Coating is placed in one operation 1″ to 2″ in thickness. The second coat for vertical surfaces should follow the first at an interval not exceeding 18 hours under normal conditions, as after final set has taken place the pores of the Waterproofed Scratch Coat, being negative in capillarity, tend to repel the grouting particles of the finish coat, resulting in a lack of adhesion.

Sometimes the architect requires the Cement Coating to be applied over the exterior face of the walls and below the pressure resisting slab of the floor, in disposition similar to that of the Waterproofing in the Membrane Method. This scheme should be discouraged, however, as the chief advantages of the Process are lost thereby.

The correct position for the Waterproof Coating is upon the inside faces of the members; that is, the Coating should be carried over the interior surfaces of the exterior walls and the upper surface of the lower level Floor Slab, and unless some special interior finish is desired the Coating should ordinarily be left exposed. It is troweled smooth to an even surface, and presents a Wall Plaster Finish and Cement Floor Finish of highest grade. When fully cured, the Coating is of light gray, uniform in color and pleasing in appearance, but if preferred it may be painted to the shade desired by employing strictly specialized Concrete Coatings.

The Waterproofing is carried continuously over all pits, trenches, etc., and either up the sides of the interior columns to the required heights or over the footings and up around the column bases to join with the Floor Waterproofing. In some cases where the construction permits, the grillages are encased in Waterproofed Concrete under the direction of the Waterproofing Contractor, and the Waterproofing of the floor carefully joined thereto.

Plate No. 1 shows a typical view of work under way. In the background a portion of the wall has been coated, while to the extreme left the surface has been chipped preparatory to receiving the Coating. The Waterproofing of the pit has been completed, and the floor and foundations in the foreground prepared and cleaned for the installation of same.

In Plate No. 2 the general scheme is illustrated for carrying the Coating continuously over various portions of the building. Particular attention is called to the necessity of insulating the Waterproofing, where abnormal conditions prevail. Upon boilers and wherever the surface will be exposed to intense heat, the Coating is depressed some six or eight (6 or 8) inches to allow the placement of a protective coat of sand and firebrick, a slab of cinder concrete or other suitable heat resisting medium. Plate No. 3 portrays the Waterproofed Coating depressed for this purpose just preparatory to the installation of the protective coat.

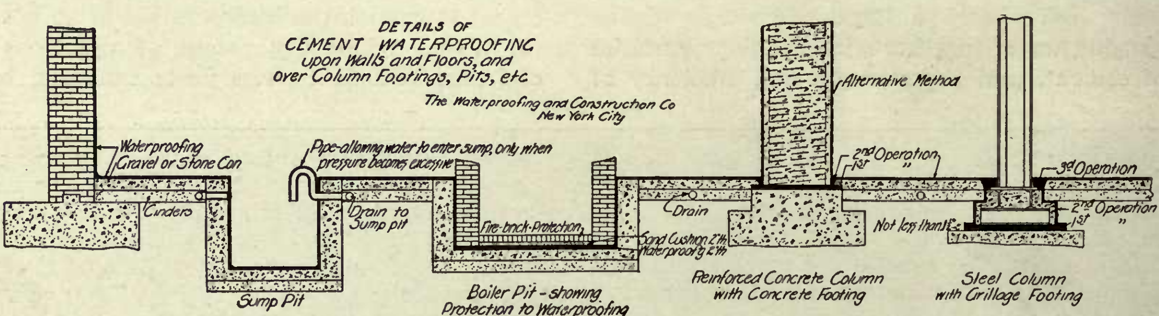


Plate No. 2

The Coating should be carried under all machine foundations, that it be not subjected to excessive vibration and that its continuity be not destroyed by the anchor bolts. Where cold water pipes enter the building, the Coating can in general be bonded to them directly by carefully removing all paint and roughening the metal. However, where hot water or steam pipes are encountered, metallic collars allowing for the lateral movement of the pipes should be supplied, the Coating bonded to the collar and a plastic material forced into the void between the collar and the pipe.

The matter of construction joints in the Coating between different day's work is all-important, as these will develop points of weakness unless they be specially treated. A fresh straight edge an inch within the edge of the completed work should be cut and this thoroughly grouted to aid in the knitting process. The joining should never be placed at the juncture between the wall and floor or at angles in walls as it is quite impossible to adequately trowel the work at these points.

Since the Waterproofed Coating is applied over the opposite face from that against which the pressure is exerted, the bond with the underlying base must be absolute. When this is attained the efficiency of the Waterproof Coating is limited in its resistance to hydrostatic pressure only by the strength of the structural member.

When the bond is positive, the Waterproof Coating forms a series of beams or arches over the minute pores of the masonry and effectively seals the water in their separate channels. The span of the beams is of course of infinitesimal length only, and thus the total force applied upon each individual beam and the consequent stresses exerted are of negligible magnitude; also it is quite probable that the pressure is lost to a large extent by the capillarity, depending for this feature upon the impermeability of the masonry itself. Only so long as the particles of water are confined within their tiny channels does the Cement Coating possess real efficiency, for if the water be allowed to collect in a continuous sheet behind the Waterproofing (which may occur when the bond is imperfect) the beams become of appreciable length and the coating is ruptured or forced from its position.

Considering these facts, it is readily perceived that the success of the Process is dependent to a very great extent upon the efficiency of the bond existing between the Waterproofing and the underlying base. Only by virtue of this bond is it possible to attain such excellent results by applying the Waterproofing upon the interior faces of the members.

The fact must be always borne in mind that the actual function of any Waterproofing agent is to make the masonry impervious and that it is not a pressure resisting medium of appreciable structural strength. Thus if a wall or floor

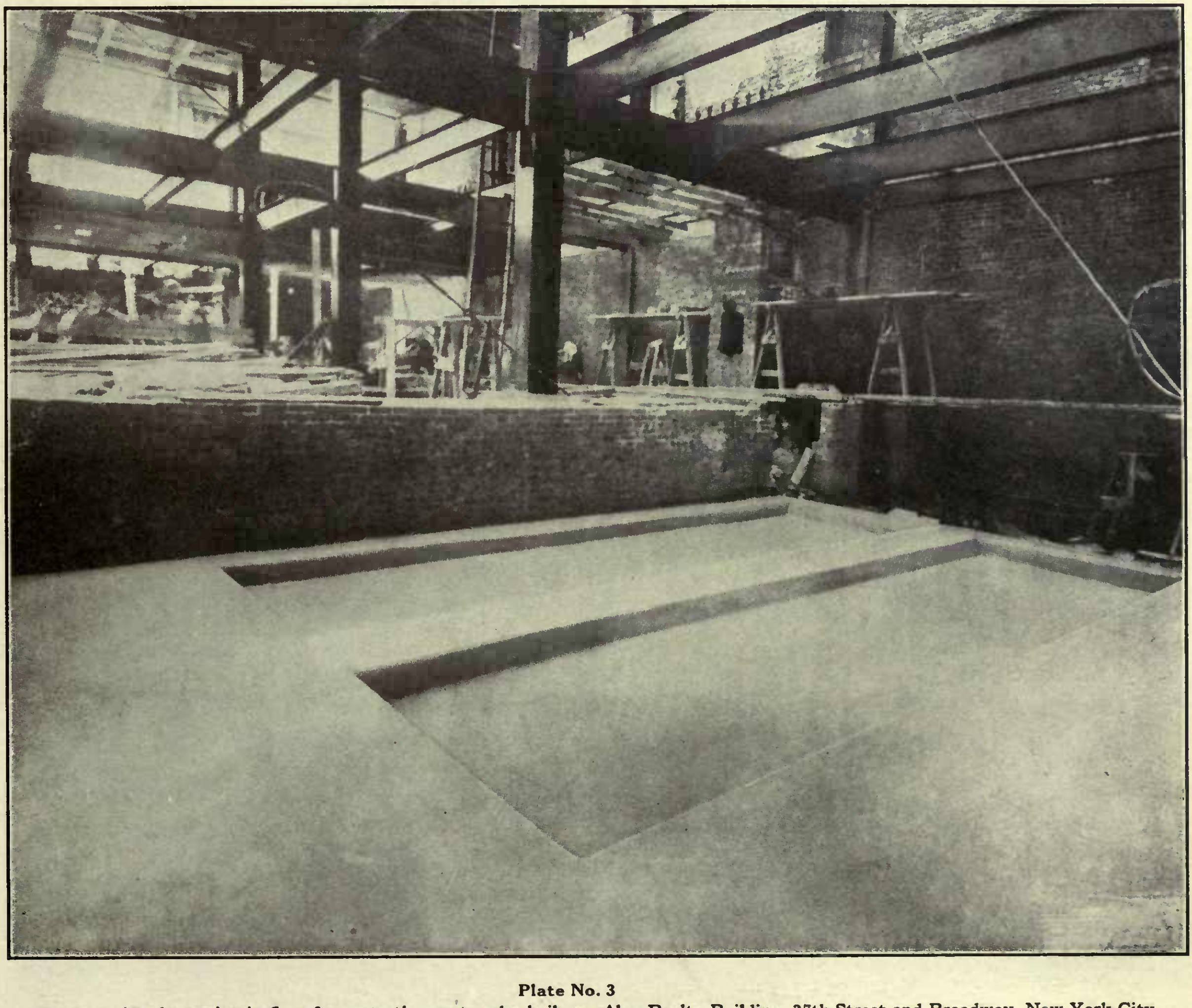


Plate No. 3

View showing depression in floor for protective coat under boilers. Alan Realty Building, 37th Street and Broadway, New York City. George and Edw. Blum, Architects. Alan Realty Const. Co., Owners and Builders.

slab, efficiently Waterproofed, be subjected to stresses beyond its ultimate strength, the member itself will fail and the Waterproofing be ruptured. Obviously this failure cannot be attributed to any fault of the Waterproofing, and in the design of a structure due allowance must be made for adequate strength of the members to resist hydrostatic pressure when such exists or is likely to exist. This truth is apparent, but in the mass of detail that enters into the design of a structure its importance is often not appreciated.

The control of water during the progress of construction work is important as the Coating, of course, is of such nature that it is unable to resist hydrostatic pressure until it has become fully hardened. Various means are devised for relieving this pressure, and no little ingenuity is required to successfully apply the Waterproofing against members through which water is percolating.

The general method of procedure in such cases for vertical surfaces, is to drill holes through the wall at various points to concentrate the flow of water. Metallic or porcelain tubes are inserted, protruding several inches from the interior surface of the wall to prevent the water from flowing over the fresh Coating. Where the floor is being simultaneously Waterproofed, rubber tubes are attached to the metallic or porcelain ones to conduct the water directly to a sump pit.

When hydrostatic pressure exists, before placing the slab of horizontal members, the best method is to construct a drainage system so that this pressure can be temporarily relieved. Excavation should be made some eight or ten (8 or 10) inches below the lower side of the proposed slab and this backfilled with cinders, gravel or similar porous material. Drains of hollow tile should be constructed at intervals, converging to sump pits. Pumping or bailing should be resorted to from these pits until the concrete has attained its initial set, and then again for some ten to fifteen (10 to 15) hours after the Waterproof Coating has been placed, or until the latter has become sufficiently set that the water will overflow the sump pit, and not seep through the Coating, as in this latter event its efficiency will be entirely destroyed. After final set of the Coating has obtained, the sump pit can be sealed.

As may be ascertained from the preceding discussion, where water exists during construction work, the walls may be erected regardless of the Waterproofing, but the floor slabs should not be placed until proper means have been taken to control the water.

Where this scheme is not followed or in the case of the repair of leaky floors, it is necessary to install drains in trenches. These should be cut entirely through the members, or at least to such depths that the flow will be concentrated, and that concrete of sufficient thickness to resist the pressure can be placed above the drains. Both of these requisites must be fulfilled. Great care must also be taken that the new concrete in the trenches be carefully bonded with the old, so as to form a continuous slab possessing adequate structural strength.

When scientifically undertaken the Cement Coating Process is absolutely positive and permanent in its results and its merits as a Waterproofing medium are excelled by no other method.

Cherry Street Wharf, Philadelphia, Pa. Snare & Triest, Contractors
All concrete waterproofed with Truscon Waterproofing Paste, *Concentrated*.

CHAPTER NINE

Practical Application of Waterproofed Plaster Coat

Manner in which Wall should be Roughened—Illustration of Roughened Wall—Why a ¾" Waterproofed Plaster Coat is Adequate—Roughening of Columns and Footings—Application of Waterproofed Plaster Coat to Columns and Footings to Prevent Electrolysis—Results of Plaster Coat Waterproofing—A Typical Illustration.

The accompanying illustration (Figure 1) shows the thoroughness with which a concrete wall is usually roughened before applying a waterproofed plaster coat. This thorough chipping and roughening insures a surface which will very firmly and securely hold the waterproofed plaster coat. The importance of this thorough preparation of the wall is appreciated when it is considered that a waterproofed plaster coat is applied to the interior of the wall and must hold the water back through the security of its bond to the surface.

With the exercise of reasonable care to roughen the surface so the plaster coat will

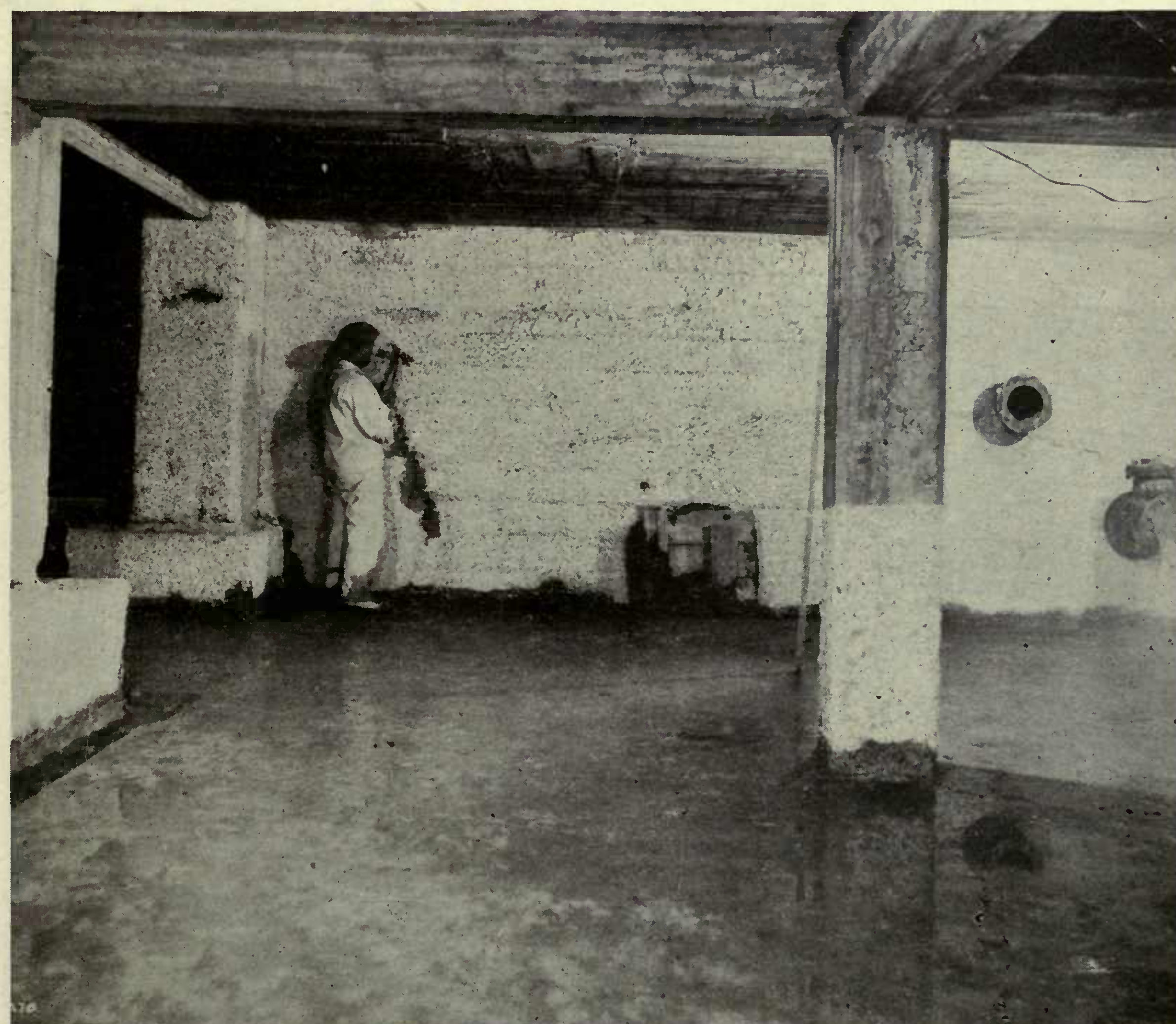


Figure No. 1

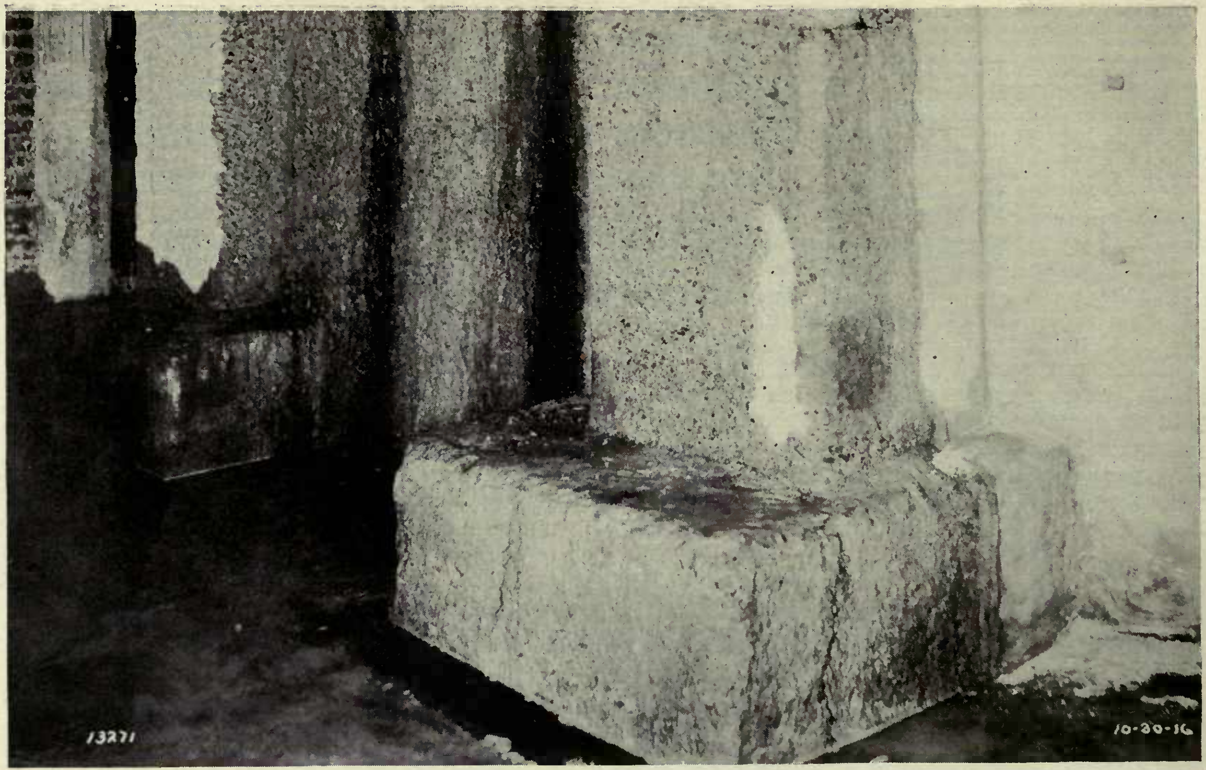


Figure No. 2

Figure No. 3

securely bond, it will positively hold back the water under considerable hydrostatic head. This is probably explained by the fact that the water in coming through the wall, follows pores and capillaries, and on reaching the waterproofed plaster coat is held right in the capillary, and its pressure considerably reduced over what would be expressed if the water could circulate and collect in considerable area and volume behind the plaster coat treatment.

Theoretically, with the water confined to the definite pores and capillaries in the concrete, even a three-quarter inch plaster coat represents a considerable thickness in comparison to the span between the points at which the plaster coat is securely bonded and fixed to the wall and the area in which the water is present in the definitely limited and defined capillarity of the concrete.

The second illustration (Figure 2) shows the same roughening treatment as applied to a column and footing. The waterproofed plaster coat is coming in quite general use for enclosing footings and grillage to avoid the penetration of any moisture and preventing any corrosion through electrolysis. The essential thing in the application of a plaster coat in such a condition is to be certain of the continuity so as to leave no opening for any moisture to work itself into the mass. This illustration also shows a section in the concrete apparently defined as a section between old and new work where the bond was not satisfactory. Observe that water has been percolating through this crack and the contractor has inserted bleed pipes to concentrate the flow before applying the plaster coat.

The third illustration (Figure 3) is a very typical example of the utility and appearance of a basement which has been protected against any moisture or dampness by the application of a plaster coat. In fact, illustrations 1 and 2 show the work in progress on the same operation that is shown in the completed form in Figure 3. It is interesting to observe the fine, attractive appearance of the walls as they are left in a smooth, polished condition after the application of the waterproofed plaster coat. Although in the illustration shown, the walls were subject to considerable hydrostatic pressure so that previous to the waterproofed plaster coat water was penetrating and percolating through the walls at various points, after the treatment as shown the walls are absolutely free from any moisture or dampness and the basement has nearly the same practical utility as any other floor.

Architects and engineers will be particularly interested in the features of this waterproofed plaster coat treatment on account of its economy and general effectiveness.

St. Paul Public Library, St. Paul, Minn. E. D. Litchfield, Architect

All foundation work waterproofed with Truscon Waterproofing Paste, *Concentrated*.

CHAPTER TEN

Relieving Pressure Before Application of a Waterproofed Plaster Coat

Method of Draining—Bleed Pipes—Siphon—Central Sumps—Complete Work of Drainage—Bleeding Wall to eliminate Slow Seepage—Practical Illustration of Bleed Pipes—Results of failure to Relieve Pressure.

In undertaking a waterproofing operation by means of a waterproofed plaster coat, it is very necessary to provide for the free flow of any water that is present either under seepage or hydrostatic pressure.

In order to get a firm and secure bond of the plaster coat it is essential that the surface be free from the movement of any water. Even moisture under the slightest seepage pressure, the occurrence of which is hardly discernible, will, when concentrated back of a waterproofed plaster coat, weaken the bond and cause unsatisfactory results.

In undertaking an operation, the method to be followed must be determined as appropriate to the existing conditions. Attention is first directed to the treatment of the walls.

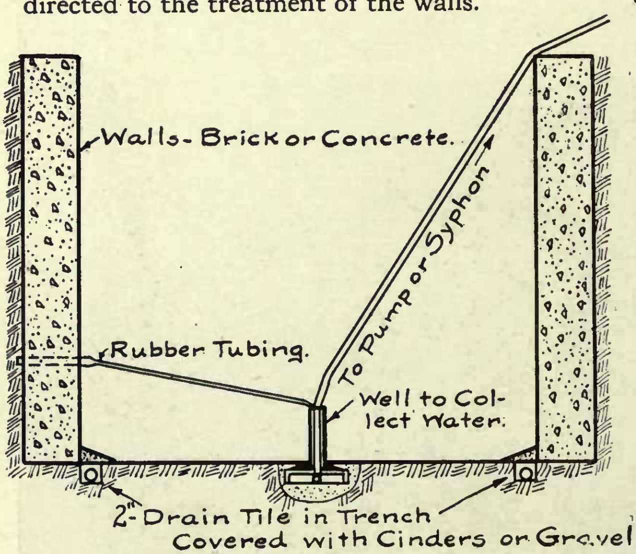


Figure 1.

Figure No. 1 illustrates a section of a wall showing the method of draining that would generally be followed. To relieve the seepage or flow of water through the wall on the left of the figure, a hole has been drilled continuously through the wall in which has been inserted a pipe which is then made continuous with a sump constructed in the center of the excavation. Any sections of the wall showing the presence of sufficient moisture to give any movement or flow must be drained by means of a "bleed" pipe before the plaster coat application can be undertaken.

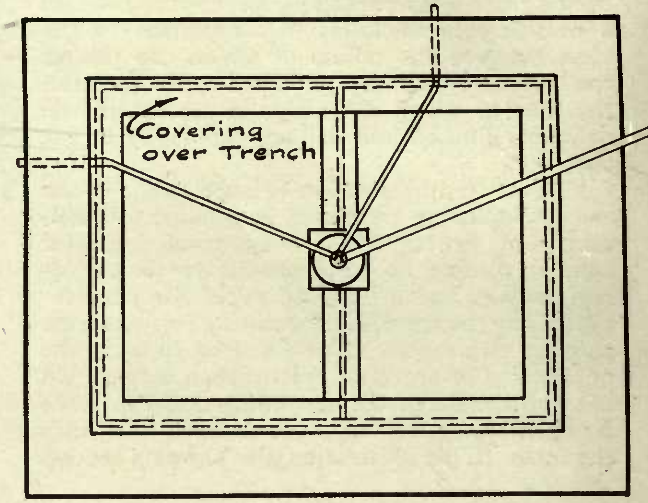


Figure 2.

Figure No. 1 also illustrates the erection of a two-inch drain tile in a trench around the foot of the wall, which is constructed to grade so as to empty into the sump where the water is relieved by means of the syphon pump.

Figure No. 2 is a plan of the same condition illustrated in Figure 1. Observe that two bleed pipes have been inserted in the wall which are connected with a syphon and the presence of the drain tile, which is covered with cinders and gravel running continuously around the outside and connected to the central sump.

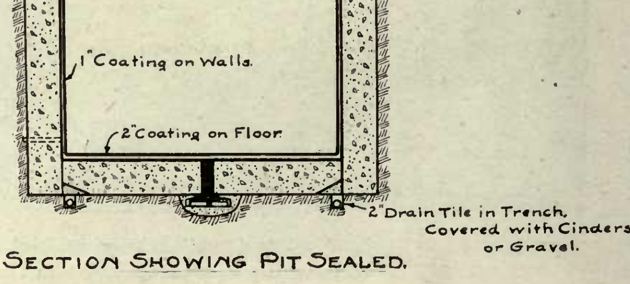


Figure 3.

With the flow of water through the wall concentrated in the sump, the surface is then in condition for application of the plaster coat. The bleed pipe should be left in operation for a matter of ten days to two weeks in order to insure proper hardening of the plaster coat before it is required to withstand the pressure.

Figure 3 illustrates the completed work. With the water draining freely into the sump and then removed by the syphon, the concrete base can be constructed and the concrete take its full normal hardness without any possible injury of water accumulating and seeping up through the soft concrete mass. The floor is finished with a waterproofed plaster coat, which is made continuous with the applications on the side walls.

After the sump has been kept in operation for a period sufficient to allow for the proper hardening and bonding of the plaster coat, the pump can be stopped and the cap screwed on top of the sump to close it. The water pressure is then entirely resisted and held back by the waterproofed plaster coat.

Figure 4 illustrates a section of brick wall through which a bleed pipe has been driven and connected with a rubber hose to a central sump. This illustration is particularly interesting, as it shows the result of having undertaken to apply a plaster coat to a surface where there was a slow seepage of water. While to the naked eye the movement was hardly discernible, as soon as the

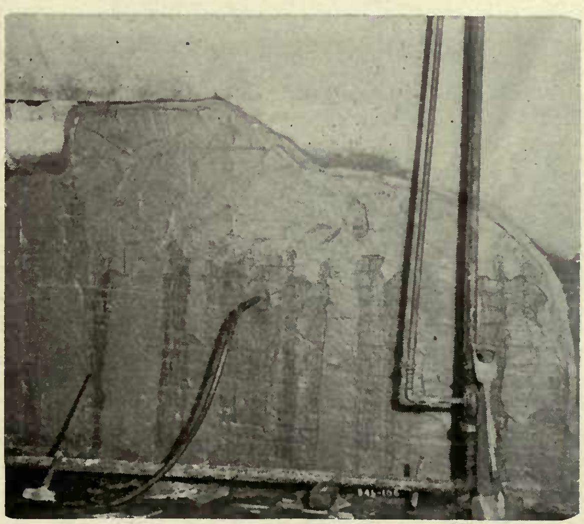


Figure 4.

green plaster coat was applied it began to be carried down on the thin film of moisture that slowly but positively accumulated back of the plaster coat and separated it from its bond and

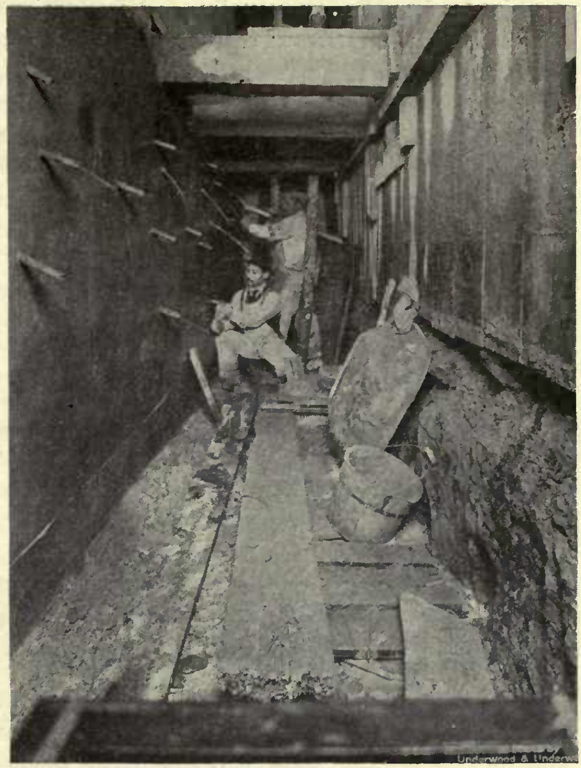


Figure 5.

contact with the surface. It was necessary to insert the bleed pipe and concentrate the flow of the water before the plaster coat could be applied safely.

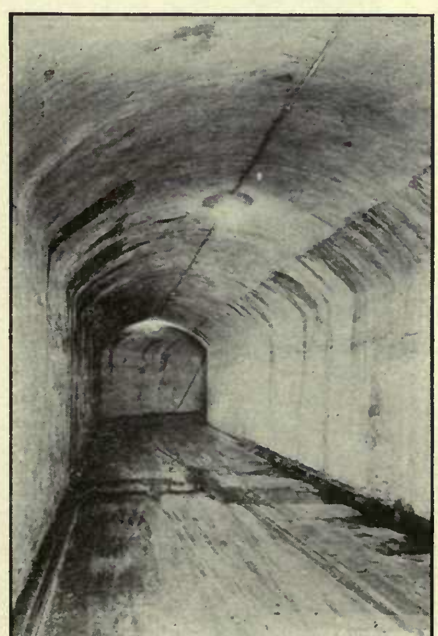


Figure 6.

Figures 5 and 8 are unusually good illustrations of the use of bleed pipes in actual practical operations. The walls to be treated showed evidences of the movement of considerable moisture. The holes were drilled into the walls in which the bleed pipes as shown in the illustrations were placed and only after the water pressure was relieved by the bleed pipes was the application of the waterproofed plaster coat undertaken.

After the thorough hardening of the waterproofed plaster coat, the bleed pipes are broken off and closed by driving in a wooden plug.

Figure 6 is a typical illustration of the result that usually follows when care is not taken to relieve the pressure. The accumulation of the moisture back of the plaster coat naturally works itself into the plaster coat, destroying the density and compactness of the mechanical pressure used in application and defeats the object of obtaining a thoroughly continuous and dense application.

Figure 7 is a little closer view of Figure 6 showing the effect of the moisture and dampness that is flowing and seeping through the imperfectly applied waterproofed plaster coat.

Figure 7

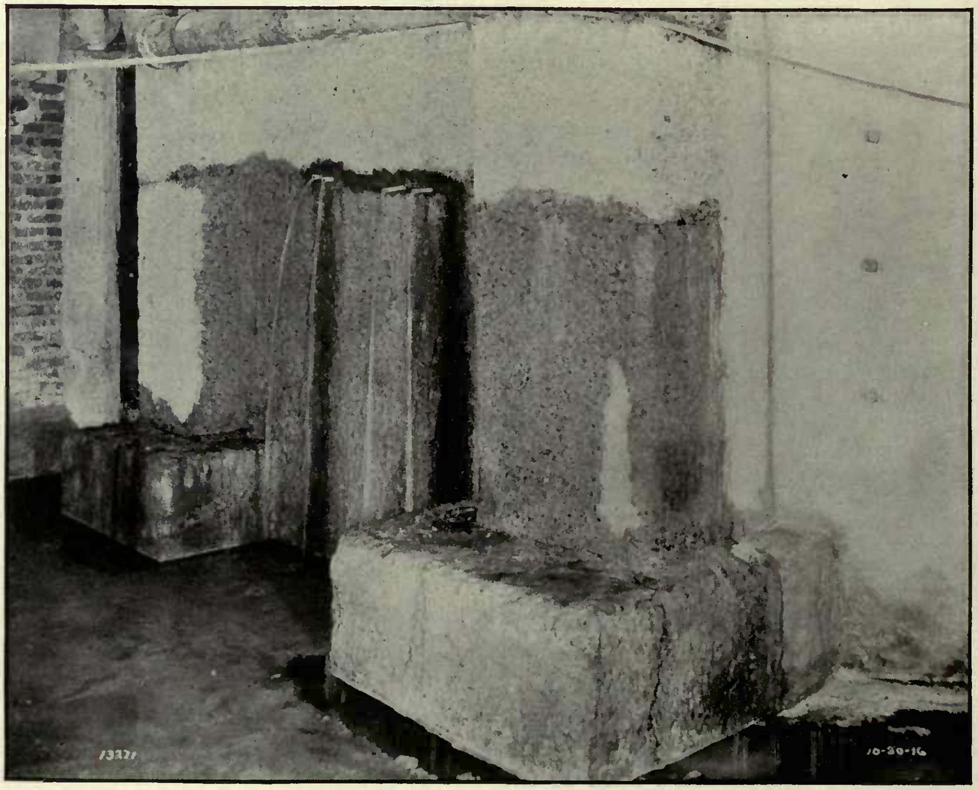


Figure 8

CHAPTER ELEVEN

Integral Waterproofing a Consistent Principle of Engineering

By R. Alfred Plumb

The use of the Safety Factor in Engineering Design—Its application to Waterproofing—Engineering not an exact Science—Safety Factor in Reality Factor of Ignorance—Definition of Exact Sciences—Illustrations—Method of Procedure in Exact Sciences—How Engineering differs from Exact Science—Why the Factor of Safety is necessary in Engineering—Concrete offers greatest Variation of all Building Materials—Why it does so—Why the Safety Factor Principle is particularly applicable to Concrete Construction—Direct bearing of this to Waterproofing of Concrete—Concluding Review and Discussion.

INTRODUCTORY NOTE: The presentation of the use of integral waterproofing in waterproofed concrete as an action consistent with the usual performance in employing a "factor of safety" (or a "factor of ignorance") is a direct and thoroughly logical application. Integral waterproofing produces waterproofed concrete and provides qualities for conserving the strength of the concrete and protecting it against disintegration. Accordingly it should have a very significant consideration as a "factor of safety" (or as a "factor of ignorance") as it is so closely and directly associated with the subject of the strength and stability of concrete.

The correct and practical present conception of the use of a factor of safety is a necessity, due to the fact that engineering has not developed to the basis of a true science and does not embrace concise knowledge of the laws of natural forces and their application to the strength and resistance of materials. Engineering is really more of an empirical consideration of practical observations and results.

If the engineer was in position from his knowledge to proceed with perfect definiteness of the strength of materials and the accuracy of workmanship, engineering in conception and practice would become a definite science. It would then be entirely superfluous to consider the use of any excess of materials over what was very definitely and positively known to be sufficient to meet the requirements of any particular structure. Actually the term and practice involved in the consideration of factor of safety would become obsolete. However the factor of safety may be more literally interpreted a factor of ignorance, due to the fact that our present engineering practices are only reasonably accurate methods of approximation.

It is such subjects as Chemistry and Astronomy that present the truer conception of an exact science. Chemistry as a science involves a very definite knowledge of the various elements that compose matter and the laws which regulate the reactions and the relationships of these various elements to each other. The chemist knows by the definite, concise knowledge of the science that when two or more of the established elements are brought together, that certain definite changes will take place and that such reactions will be in accordance with very definitely predetermined scientific facts.

Astronomy is even a better illustration of an exact science. Due to the mathematical accuracy with which the knowledge of this subject has been developed, the position of the sun, the moon, and the stars are determinable for almost any time. The position of the sun one year from today is not a matter of empirical deduction or of approximate determination but a fact which can, from the conciseness of Astronomy as a science, be precisely determined by mathematical calculations.

It is when any subject reaches that point of development where its laws can be determined with mathematical precision, and then can be accurately expressed in practice, that the particular subject reaches a really true scientific basis.

While engineering design is based on mathematical calculations, there are so many uncertainties involved in the qualities of materials and workmanship that engineering cannot, when considered in relationship to its practical execution, be accepted as mathematically concise.

By laboratory tests, it is possible to determine the strength and qualities of any specific material under ideal conditions, but the engineer must substantially discount the laboratory tests to anticipate the variations in the quality of such materials when used in actual, practical construction.

In design, the engineer, while he can be quite confident of the accuracy of his knowledge of a few of the simpler stresses, such as direct tension and compression in members subject to flexure, there are so many complicated stresses that will develop that the engineer does not understand that he is compelled to use materials at unit stresses, much less than their ultimate strength, in order to provide for the uncertainties in stresses that he does not understand.

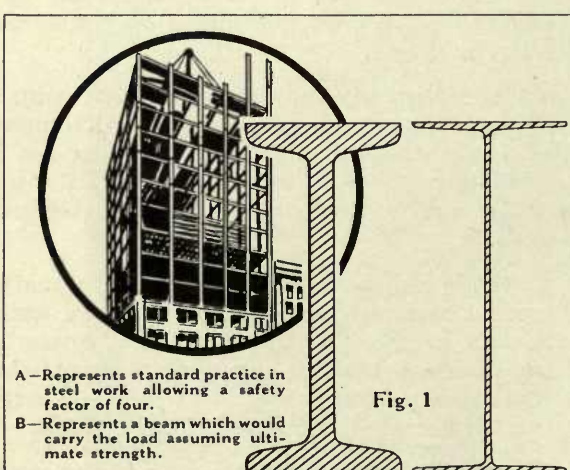
For instance, in any beam or girder there are developed such additional stresses as horizontal and vertical shear and diagonal tension and compression stresses which vary so much in different parts of their members, and combine themselves in such ways, that the engineer at times is unable to actually determine their direction of action, much less being able to calculate with any accuracy even their approximate intensity.

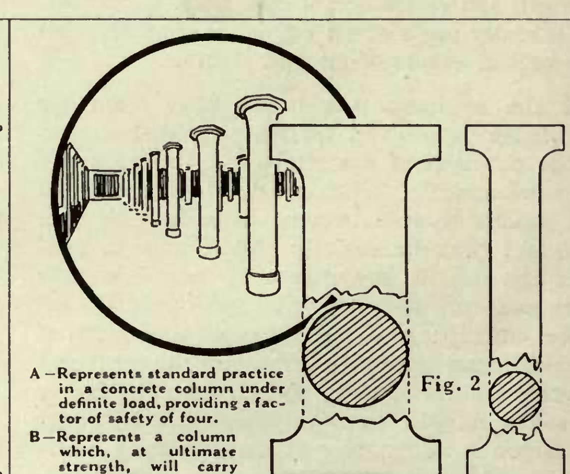
It follows logically that the real, practical conception of the "factor of safety" is more a "factor of ignorance," as the engineer is required to use excessive amounts of materials in order to insure protection against variation in the quality of materials, in the uncertainties in workmanship and the actual lack of concise knowledge of the intensity and direction of the stresses that will develop in the structure.

The engineer can be concise and accurate in the mathematical calculations of his design, but he cannot extend the same mathematical precision to the examination of the interior of every piece of material that enters into the construction to determine the extent of flaws and imperfections that are likely to be present. It is recognition by the engineer of the fact that he cannot make this internal examination of the structure of the materials that compels him to figure the unit stress of any material at a value which is only a fraction of the full ultimate strength.

In design no engineer will make a building stronger than he believes will actually be required, but he uses the lower stresses because his lack of knowledge in the variation in conditions involving materials, workmanship, and stresses is such that he dare not go further. The engineer often finds himself groping in the dark, and occasionally when he becomes a little too confident in the uniformity of materials, a little too courageous in depending on the human element of workmanship, a little too certain in his ability to concisely figure strains and stresses, he is confronted with a Quebec disaster that is sure to intimidate and to bring greater emphasis on the necessity of a care and caution in proceeding on facts that are really positively and definitely known.

It is that recognition in the mind of the engineer that, between the accuracy of his calculation of stresses that are known and the expression of his design in actual material form, there are so many uncertainties, so many qualities of which he is uncertain that he realizes he cannot draw his design closer to the actual ultimate but must provide excessive materials to compensate for what he does not know and what he cannot accurately determine.





Illustrating the use of the "safety factor" in general construction work.

The amount of space that has been given in the foregoing to a discussion of the conception of "Factor of Safety" is intended to establish in the reader's mind the general extent to which the engineer recognizes his limitations in engineering as a science, and must secure and protect himself on things he does not know by use of materials figured at ultimate stresses only representing a small percentage of the actual ultimate value.

The effort has been, not so particularly to give the reader information that he does not know, but bring to his mind in concise, defined perspective the exact reasoning why a factor of safety is used. These facts are not theory but absolute practice.

Now, considering the various types of constructive materials, what one stands out most specifically as offering the biggest opportunity for variation in actual construction? The answer is—Concrete.

The reader recognizes steel as a product of thoroughly standardized manufacture, yet, due to lack of confidence in what is actually known about steel and what it will do under various conditions of stress, the engineer employs from two and a half to four times more than if figured at full, ultimate value.

Similarly with wood, a product of Nature's laboratory, the engineer has not sufficient confidence in his knowledge of its uniformity or of its behavior under various loadings but what he provides from seven to twelve times more actual material than would be required if it was figured on the basis of its ultimate strength.

If the engineer's confidence in steel and wood and materials of a similar type is so limited, what can be his actual confidence in a material like concrete with a vastly greater opportunity for variations? In concrete there is fluctuation that is associated with different brands of cement, there are the differences in the time of setting, there is the variation in the fineness and the strength, etc. In the aggregate, there is probably the widest variation of any type of raw material entering into the actual finished construction. It not only varies in different sections but in the same locality there is considerable difference. In one section of the country, a crushed rock is used in preparing concrete and there is associated with it a great deal of fluctuation due to the inherent nature of the rock itself. In other sections gravel is employed with a wide fluctuation in its granularmetric composition. In fact almost unlimited comment could be made bearing on the varieties of aggregates employed in concrete.

Further, there is the influence on the finished concrete by the method of mixing, the amount of water used, the time of mixing, the method of placing, spading, tamping, curing, etc.

It requires little comment to bring to the reader's mind, in very forceful vision, that when he is proceeding to figure a factor of safety as a method of protecting against the wide uncertainties and unknowns of structural materials, there is hardly any material that requires the same attention or the same provision for factor of safety as concrete.

It is the association of the two facts that a factor of safety is employed as a protection and a security against the uncertainty in materials, workmanship, etc., and in these qualities of indefiniteness and uncertainty that concrete stands out pre-eminently, that we conclude that any provision that will add any definiteness or positiveness to the production of a waterproofed result in concrete should be employed and figured as a reasonable, economical factor of safety.

It is occasionally suggested that by a scientific grading of aggregate a density can be produced in concrete that makes it impermeable. The interesting part of this statement is the word "scientific." The correctness of the assertion is to be granted with the provision of the possibility of an execution of the scientific requirement. It is exactly the fact that concrete among structural materials does not permit a scientific expression in result that this statement falls far short of any real significance. To accept such a possibility is to accept conditions prevailing in engineering practice that will enable us to use ultimate stresses rather than only fractions of ultimate value in practical construction.

It is not the purpose of the discussion of this chapter to show by analytical consideration that it is a physical impossibility to actually obtain waterproofed concrete by scientific grading, but simply to bring to the engineer's mind the positive inconsistency of conceiving a thing in his mind as a possibility which he cannot apply in any other phase or feature of engineering practice. The engineer today who recommends a scientific grading of aggregate as a method of producing impermeable concrete must in the same breath endorse the use of ultimate stresses in steel, wood, and other structural materials.

Laboratory

THE TRUSCON LABORATORIES

Quality

PART II

Discussion of Truscon Waterproofing Paste, *Concentrated*

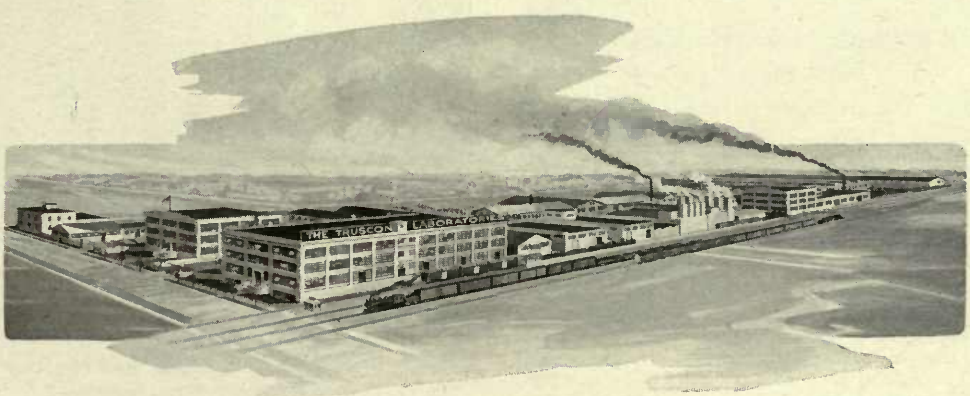
Nature of Truscon Waterproofing Paste, Concentrated—How Used—Method of Incorporating Truscon Waterproofing Paste, Concentrated, in the Concrete—Its Economy—Colloidal Nature of Truscon Waterproofing Paste, Concentrated—Effect on Concrete—General Directions for Use—Table of Quantities—Illustrations—Reports—Testimonial Letters—Prominent Users.

ANY integral waterproofing compound to successfully serve its purpose must have the following characteristics:

It should be simple to use. It should readily mix with water, as water must be its distributor. It should be so economical as to permit of general use. Its effect must be permanent. Finally it must be of such a chemical composition that the strength of the finished structure shall not be one particle lessened by the possible increase.

Truscon Waterproofing Paste, *Concentrated,* is the one product which effectively meets all of these requirements. Developed by many years of experiments and now tested and proved by successful use in thousands of structures, it is recognized by engineers as the one standard product for waterproofing by the integral method.

The following pages set forth the nature and qualities of Truscon Waterproofing Paste, *Concentrated,* and serve to explain the extraordinary success this product has gained.



The Truscon Laboratories, Detroit, Mich.

A. Krolik & Co. Building, Detroit, Michigan
Albert Kahn, Architect, Ernest Wilby, Associate
All concrete below grade line waterproofed with Truscon Waterproofing Paste, *Concentrated*. The Detroit River is directly back of the building.

Simple to Use

The method of using TRUSCON Waterproofing Paste, *Concentrated,* is the simplest possible. All that is required is to add this Paste to the water which is used to temper the dry mixture of cement, sand, stone, etc. No other method is so easy, rapid and convenient.

When powder compounds are used for waterproofing they must be mixed with the dry cement. This operation involves considerable delay, as well as extra labor cost. By the TRUSCON method there is no hindrance to rapid, economical work.

Readily Mixed with the Gauging Water

Because it comes in paste form, TRUSCON Waterproofing Paste, *Concentrated,* mixes very readily with water, forming a milk-like solution. It distributes itself evenly throughout the water and hence is carried uniformly to every part of the mortar or concrete.

To produce a perfect mixture between ordinary oils and water is of course impossible. It is for this reason that most of the dry powders offered for waterproofing purposes are more or less inefficient, for they consist of chemically insoluble soaps with hydrated lime, and such metallic salts of fatty acids, as is well known, are naturally repellent to water. Consequently, these waterproofing compounds do not become evenly distributed throughout the concrete and thus they cannot fulfill their purpose of waterproofing it. This result comes partly because of the difficulty of mixing such dry compounds with the cement. However, even were a perfect mixture obtainable, nevertheless the waterproofing compounds, being lighter than the cement, sand, etc., naturally float toward the top of the mixture as soon as the water is added.

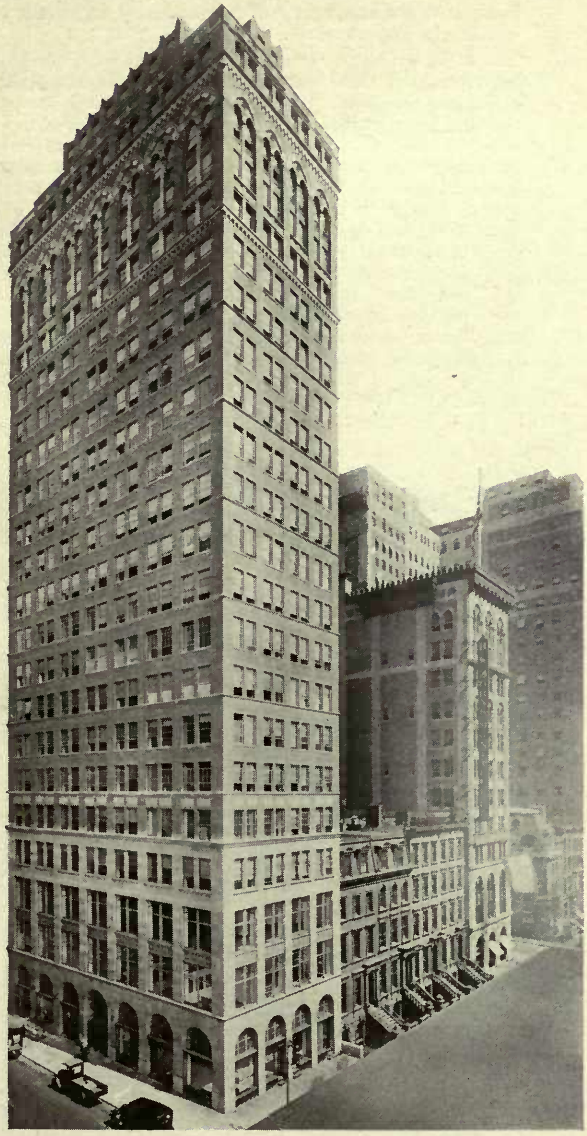
The use of a dry powder for waterproofing purposes involves a difficulty such as would follow an attempt to evenly mix and hold in distribution finely pulverized cork. It is obvious that when the mass is very heavy and dry the cork is entrapped and mechanically held, but as soon as any fluidity is produced, as by the addition of water, the cork, due to its repellent nature, naturally works itself to the top of the mass, entirely destroying the original distribution.

Because TRUSCON Waterproofing Paste, *Concentrated,* readily mixes with the gauging water and thus becomes evenly distributed throughout the concrete, its waterproofing qualities safeguard every part of the concrete. There can be no weak spots where leaks may develop. Moreover, its protection against water does not weaken with age but on the contrary becomes stronger.

Most Economical Waterproofing Compound

A lower cost results from the use of TRUSCON Waterproofing Paste, *Concentrated,* than with any other integral waterproofing treatment. This is the case because of the concentrated nature of the Paste and because it contains no fillers like hydrated lime, clay, silica, etc., which

Notre Dame Cathedral, New York City
Cross & Cross, Architects
Waterproofing & Construction Co., Waterproofing Contractors
Truscon Waterproofing Paste, *Concentrated,* used to Waterproof Concrete Work



Rheinstein & Haas Building, New York, N. Y.
Starrett & Van Vleck, Architects
Rheinstein & Hass, Contractors

increase the bulk of many other waterproofing compounds without raising their efficiency. In TRUSCON Waterproofing Paste, *Concentrated,* only materials of the greatest waterproofing value are used; and hence this product, even though its cost were considerably higher, would remain the most economical to use.

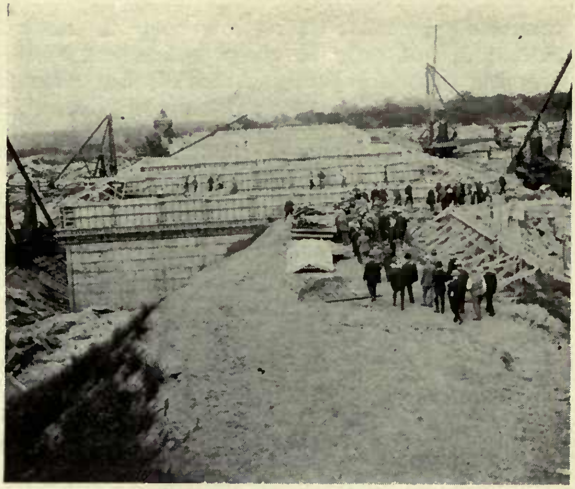
The wide recognition of TRUSCON Waterproofing Paste, *Concentrated,* as the standard product for the integral method of waterproofing, has come because it combines the qualities of simplicity and efficiency, together with the lowest unit of cost. Thus, TRUSCON Waterproofing Paste, *Concentrated,* has brought about the more general use of waterproofing in concrete. Because of its low cost its use has extended, not only to structures where waterproofing was absolutely essential, but also to work where waterproofing was merely desirable.

Colloidal in Composition

Portland cement mortar, as is well known, is partly waterproof. This results because of a jelly-like or colloidal substance in the cement, which tends to fill up the pores. TRUSCON Waterproofing Paste, *Concentrated,* is itself colloidal in nature; hence it completes the waterproofing tendency of the cement by entirely filling the pores in the mortar or concrete. It thus protects fully against the softening tendency of water and does this not only efficiently but permanently.

Careful study of those chemical and physical processes which take place when Portland cement is mixed with water has made it evident that to give satisfactory results a waterproofing compound must necessarily be of a colloidal nature. The process of

Statler Hotel, St. Louis, Mo.
Mauran, Russell & Crowell and Geo. B. Post & Sons, Associated Architects
Construction work below grade waterproofed with Truscon Waterproofing Paste, *Concentrated.*



Rochester Sewage Disposal Plant,
Department of Engineering, City of Rochester, Engineers
C. Arthur Poole, Supervising Engineer
Concrete Waterproofed with Truscon Waterproofing Paste, *Concentrated*

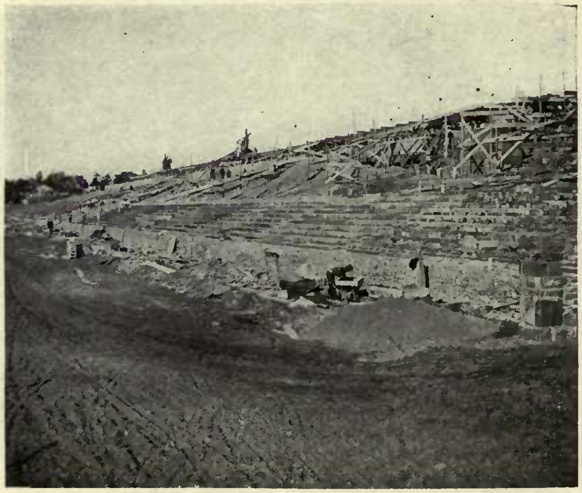
setting and hardening of Portland cement mortar and concrete is not alone a process of solution, hydration and recrystallization, but is supplemented by the formation of a colloidal substance which surrounds and protects the crystals of cement that bind the particles of sand and stone together.

The partial degree of waterproofness which is characteristic of Portland cement mortar and concrete is due entirely to the presence of its colloidal constituent. In its absence there would be no medium to protect the crystallization against the action of water which would tend to gradually soften, dissolve and disintegrate the mass when subjected to actual practical exposure.

This colloidal substance, however, is never formed in sufficient quantity to entirely fill out all the voids in the mass, and it is accordingly the function of an efficient integral waterproofing not only to intensify the formation of the colloid originating from the cement itself, but to add a sufficient quantity of colloid so as to fill out the voids and impart to the concrete sufficient density to render it absolutely impermeable.

It is a further essential of an efficient integral waterproofing that the body not only be originally colloidal, but have the property of indefinitely retaining its colloidal development. Such absorbent colloids as clay, hydrated lime, aluminum hydroxide, etc., which have been used with very questionable success, have been found in time to dehydrate, losing their colloidal development, and are very slow and inactive in reverting to the colloidal condition. This behavior undoubtedly explains the very inconsistent results obtained with products of this character, as in some cases where conditions are particularly favorable for maintaining the colloidal condition, results will be quite satisfactory, but generally where there is any opportunity for the drying out of the colloid, the waterproofness is destroyed.

Concrete Stand Pipe Singson Water Works, Philippine Islands
All concrete waterproofed with Truscon Waterproofing Paste, *Concentrated.*



Cornell Stadium
Gibb & Waltz, Architects
Truscon Waterproofing Paste, *Concentrated*, used throughout all Concrete

Not Weakening the Concrete

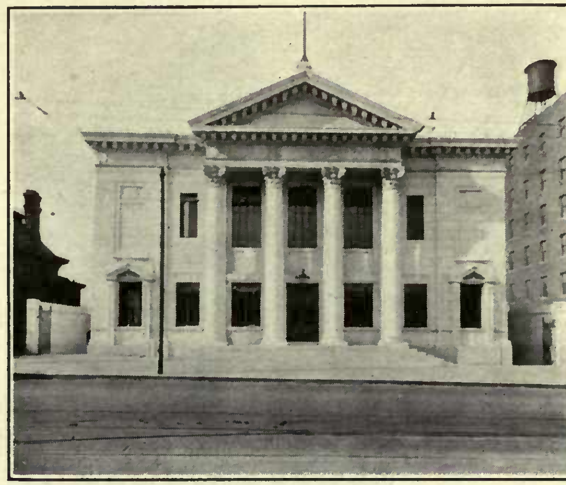
The strength of concrete ought not, of course, to be sacrificed for waterproofness. The favor with which TRUSCON Waterproofing Paste, *Concentrated*, has always been received by engineers, follows partly because, far from reducing the strength of concrete, this product enhances and maintains it. It does so because, as already explained, it protects the concrete against the disintegrating action of water.

Compounds containing large percentages of free fats, soluble soaps, active silicic acid, etc., invariably reduce the strength of concrete materially, for these products react seriously with the constituents of the cement and interfere with the normal process of hardening that is essential to develop the full strength.

A Record of Success

Even at its introduction TRUSCON Waterproofing Paste, *Concentrated*, was recognized as possessing qualities that should make it most efficient and satisfactory. Now that its success has been demonstrated in a practical way by its use in great numbers of important and extensive operations, its reliability has become a matter of general recognition among engineers and contractors. The range of work upon which it has been used is consequently very wide; indeed, it embraces practically the entire field of concrete construction, including foundations, dams, tunnels, reservoirs, tanks, floors and all similar structures. The illustrations and letters in this book refer to a few examples of these uses.

The simple method of employing TRUSCON Waterproofing Paste, *Concentrated*, is defined on succeeding pages in the form of general specifications. Upon request special specifications will be furnished showing in detail the method of using this product in the case of any unusual waterproofing problem.



Federal Reserve Bank, Atlanta, Ga.
A. Ten Eyck Brown, Architect, W. C. Spiker, Structural Engineer
Allen J. Krebs, Contractor
All concrete sub-terra construction and floors waterproofed through with Truscon Waterproofing Paste, *Concentrated*.

Ford Service Building, Long Island City, N. Y.
Concrete Foundations and Floors Waterproofed with Truscon Waterproofing Paste, *Concentrated*

Directions for Using TRUSCON Waterproofing Paste—*Concentrated*

Only ordinary care and reasonable attention are necessary to obtain the very best results with this product.

In the general integral waterproofing of mass concrete, TRUSCON Waterproofing Paste, *Concentrated*, should be employed in the proportion of one (1) part of Paste to thirty-six (36) parts of water, which provides the most economical waterproofing available.

For conditions that are particularly extreme, due to small mass or especially high pressure, the *Concentrated* Paste should be used in the proportion of one (1) part of Paste to twenty-four (24) parts of water, but under average conditions of waterproofing the Paste can be employed in the proportion of one to thirty-six (1:36) as previously recommended.

For a waterproofed cement plaster coat, the *Concentrated* Paste should be employed in the proportion of one (1) part of Paste to eighteen (18) parts of water.

The best results are obtained by thoroughly mixing one part Paste with an equal volume of water and while stirring vigorously add sufficient more volumes of water to give proportions required above.

The milky solution resulting from the mixture of Paste and water in the above proportion should be used in place of clear water to temper the dry mixture of cement and aggregate.

In case the mixture of Paste and water is allowed to stand for any interval between using, it should be most thoroughly stirred to insure an even and uniform solution each time just before using. The Paste diffuses so readily that this imposes no additional trouble, as very little agitation will insure its perfect distribution.

The following table gives the quantities of cement, sand and TRUSCON Waterproofing Paste, *Concentrated*, required for a 1:2 waterproofed plaster coat to cover 100 square feet of surface.

Proportions	Thickness	Bbls. Cement	Cu. yds. Sand	Pounds Paste
1 part Cement	1″	1.00	.28	8
2 parts Sand	¾″	0.75	.21	6
Area 100 sq. ft.	½″	0.50	.14	4

Hotel Biltmore, New York, N. Y.

Truscon Waterproofing Paste, *Concentrated,* used in construction of this building.

TRUSCON Service

Waterproofing and dampproofing problems have been the province of The TRUSCON Laboratories for many years. Its organization includes a corps of expert chemists and chemical engineers, whose advice upon special problems in this field is at your disposal. This service is without charge or obligation—do not hesitate to avail yourself of it at any time.

Elks Building, New Orleans, La.
Toledano, Wogan & Benard, Architects
All mortar used in brick work waterproofed with Truscon Waterproofing Paste, *Concentrated.*

Transportation Building, Atlanta Ga.
A. Ten Eyck Brown, Architect, W. C. Spiker, Structural Engineer
Gude & Company, Contractors
Truscon Waterproofing Paste used in all retaining walls, floors and other concrete coming in contact with the ground.

Bangor, Me. High School

Architects, Peabody & Stearns. Contractors, George H. Wilber & Sons
Difficult Leakage Remedied by Truscon Paste, *Concentrated*

STOPS STUBBORN LEAKAGE

Bangor, Maine, November 17, 1914.

The Truscon Laboratories,
Detroit, Mich.
Gentlemen:

In justice to your product, Truscon Waterproofing Paste, we wish to say that in the new Bangor High School we met with a particularly stubborn leakage in the basement and, after some deliberation on the part of the School Board and our firm, we concluded to use your product, namely, the Truscon Waterproofing Paste, and proceeded to use the same as per your instructions. The floors of the two rooms which we waterproofed had been finished, but we simply went over them with your Waterproofing Paste in a plaster coat one inch (1") thick and continued same up the walls to a ground two feet (2') above same, and on completion of this work had it absolutely waterproof.

We do not know that there is anything more to say in regard to this work, but we wish to further add that on the writer's own residence in Old Town, Maine, he has used this Paste in his stucco work on the second story, which has proved absolutely waterproof and, after several driving storms, south and east, there are no indications of any dampness whatever. Further along he used your "Stone-Tex" on his outside veranda floor, and after using only one coat the waterproofing is absolutely perfect, draining everything to the outlet.

If there is anything more we can say in regard to our highest approval of your products, we will be only too pleased to do so.

Yours very truly,
GEORGE H. WILBUR & SONS.

Municipal Pier No. 78, Philadelphia, Pa.
Snare & Triest Co., General Contractors

This pier extends 1,000 feet into the river. All concrete waterproofed with Truscon Waterproofing Paste, *Concentrated.*

EIGHT FEET FLOOD WATER—BASEMENT STAYED DRY

Rochester, N. Y., April 3, 1916.

The Truscon Laboratories,
Detroit, Mich.
Gentlemen:

In 1915 we erected for George C. Buell & Company in this city a new warehouse building and due to the close proximity of this building to the Genesee River, we waterproofed the basement walls and floor with TRUSCON Waterproofing Paste.

The building has recently undergone a most severe test from flood water and we have no doubt you will be interested to learn of the successful outcome of the waterproofing work.

The basement floor is two feet below the normal water level in the river and taking into consideration the possibility of the river overflowing its banks at flood time, the floor was heavily reinforced to resist hydrostatic pressure and the concrete floor slab, together with the 14" concrete walls of the basement to a point 12" above grade, was waterproofed by adding TRUSCON Paste to the water used in tempering the concrete.

The water rose to a height of over eight feet, overflowing the river banks, completely surrounding the building, at one time reaching a height of nearly 12" above grade on the street side. The basement interior, walls and floors remained at all times as dry as in midsummer, the only water coming in was that which seeped in through the basement windows (when same were half under water), through form wires which had been left in the wall and in a few instances not properly plugged, and through some water coming into the basement through the backing up of the sewer. The concrete work we found to be absolutely impervious to dampness and feel that the use of the waterproofing paste has been entirely successful.

We are quite enthusiastic over the performance and have no hesitancy in approving the use of the material for all waterproofing work.

Thanking you for the assistance and personal attention given this work at the time of construction, we are,

Very truly yours,
C. A. LIVINGSTON,
For Walker, Livingston & Brackett.

George C. Buell Company's Warehouse, Rochester, N. Y.
Walker, Livingston & Brackett, Architects

Basement waterproofed with Truscon Waterproofing Paste, *Concentrated.* The letter printed above shows how effectively Truscon Paste waterproofed this basement as demonstrated by the Rochester flood.

MOFFETT & SONS
Wholesale Grocers

Flint, Mich., May 27, 1913.

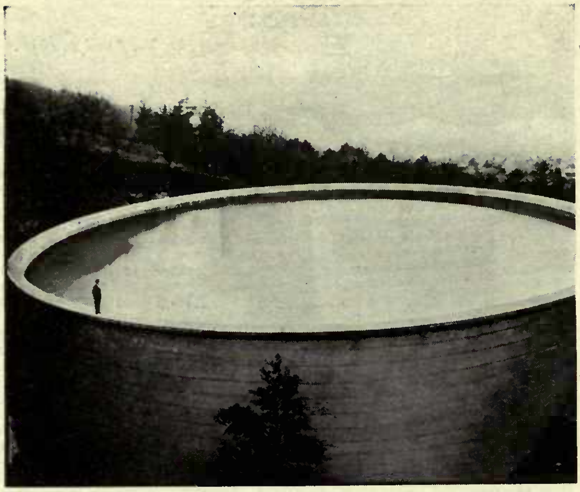
The Truscon Laboratories,
Detroit, Mich.
Gentlemen:

Last summer, as you are aware, we erected a building in this city for the accommodation of our Wholesale Grocery Business. The location on which we erected this building—while ideal from a distributive point of view, being in the heart of the business district—is near the river and the floor of our basement being necessarily several feet below the level of the river, caused us considerable anxiety as to the results of our efforts to insure a dry basement. We had previously received through the mail some of your printed matter relating to TRUSCON Waterproofing Paste, and having faith in your statement that this paste would actually make concrete mixture waterproof, we purchased enough to cover the necessary requirements for waterproofing the basement floor and walls to a height of one foot above the ground level. We used this paste strictly in accordance with your instructions, and it affords us pleasure to assure you that the results are most gratifying, for notwithstanding the fact that our building stands on porous ground and sandy soil, and as before stated the basement floor is lower than the level of the river, we have an absolutely dry basement, which means to us another story added to our building, which we believe would not have been possible were it not for the fact that we used your TRUSCON Waterproofing Paste in our concrete mixture.

We are building another block of two stores this summer in a similar location and have specified that TRUSCON Waterproofing Paste must be used in floor and wall construction.

Assuming that the foregoing information may be of interest to you, we are

Cordially,
MOFFETT & SONS.



Municipal Reservoir, Asheville, N. C.
Thoroughly and Permanently Waterproofed with Truscon Waterproofing Paste, *Concentrated*

A CONVINCING REPORT

Asheville, N. C., October 15, 1910.

The Truscon Laboratories,
Detroit, Mich.

This reinforced concrete reservoir, built to insure an auxiliary or emergency supply for the water system of Asheville, N. C., has a capacity of 5,000,000 gallons of water. The reservoir is 150 feet in diameter at the bottom and is 40 feet deep. The wall is three and one-half feet thick at the bottom and tapers to a thickness of eight inches at the top.

As originally constructed the reservoir was not satisfactory, but has been brought to stand a thorough test and has just been accepted by the city after additional work, which was done by Mr. George H. Davidson, a contractor of Asheville. The bottom of the tank, when Mr. Davidson began work on it, was from two to six inches thick with concrete filling up the crevices and the entire floor of the tank was cracked very badly. The sides of the tank were originally built in five-foot sections, and at these seams there was a constant leakage. At some places there were cracks up and down the wall, while nearly all of the wall was porous and water seeped through. Mr. Davidson broke out all of the old bottom entirely around for a distance of two feet from the wall, going down to solid rock and cleaning out all cracks and crevices. He then filled all with good concrete mixed with TRUSCON Waterproofing Paste to the level of the old floor. On top of this he laid the 8-inch floor with ½-inch reinforcing steel, filled with TRUSCON Waterproofing Paste and concrete as per TRUSCON specifications, using fifteen barrels of the Paste in the bottom. He then cut out all joints on the wall and filled them with cement mortar mixed with TRUSCON Waterproofing Paste.

Mr. Davidson's contract was "no pay if not water-tight" after a test of 90 days with reservoir full of water; and at the end of 90 days the mayor and five aldermen examined the reservoir and found that he had complied with his contract and made good. Quite a number of outside firms made bids for waterproofing of this reservoir, the lowest bid of these being in the neighborhood of $20,000, while the cost under Mr. Davidson's plan was $11,400, and he made some money. A number of firms making waterproofing material solicited this business but after demonstrations and examining the merits of the various waterproof materials, Mr. Davidson told me that he had decided that TRUSCON Waterproofing Paste was the best material to use; and he used it and made good.

N. BUCKNER,
Secretary Asheville Board of Trade.

TWO YEARS LATER

Ashville, N. C., December 14, 1912.

The Truscon Laboratories,
Detroit, Mich.

Gentlemen:

Referring to your booklet, "Science and Practice in Waterproofing," in which you show an illustration of the Asheville Auxiliary Reservoir with description of its repairs made by the writer.

It gives me pleasure to state that this tank is still in good shape, and I am sending you under separate cover a new picture, which was made about two or three weeks ago.

Yours very truly,
N. BUCKNER, Secretary.

FOUR YEARS LATER

Asheville, N. C., March 20, 1914.

The Truscon Laboratories,
Detroit, Mich.

Your telegrams received. I have sent the following message to-day: "Our big auxiliary concrete reservoir water-tighted in nineteen ten with TRUSCON Waterproofing Paste by Geo. H. Davidson, a local contractor, has been and is now satisfactory. Prior to that time, could not be used."

N. BUCKNER,
Secretary Asheville Board of Trade.

SOHO PUBLIC BATHS

2410 Fifth Avenue, Pittsburgh, Pa.

The Truscon Laboratories, January 31, 1912.
Detroit, Mich.

Dear Sirs:

Regrading the waterproofing of the Soho Baths with your TRUSCON Paste, will say that the same is perfectly satisfactory.

Our condition was rather extreme; the building is situated on Fifth Avenue, 3 stories above and 3 stories below Fifth Avenue. Our front wall extends down 36 feet below the street, being 12½ feet thick at the bottom, composed of concrete.

The water backed up against the wall from springs in the hill and came through a dozen different places, running continually at all seasons of the year at 100 gallons per hour. By applying a plaster coat ¾-inch thick 1:2, mixing the TRUSCON Paste to the water, we have secured a water-tight job and our walls are now perfectly dry, enabling us to utilize the floors below Fifth Avenue and make a swimming pool in which we have used the TRUSCON Paste with satisfaction.

The walls were so dry that the carpenter, thinking there was no water back, drilled through the plaster coat to fasten partition, when instantly the water gushed forth in a stream with much pressure, proving conclusively that your material is a thorough waterproof, and we will always use it in our waterproofing.

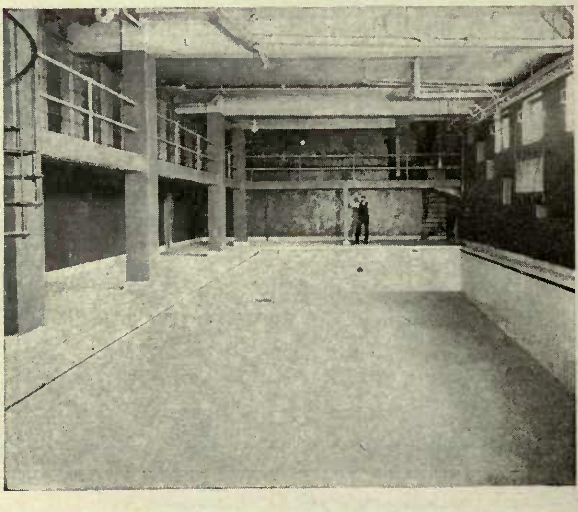
Yours truly,
D. P. MARSHALL,
Superintendent.

Pittsburgh, Pa., March 20, 1914.

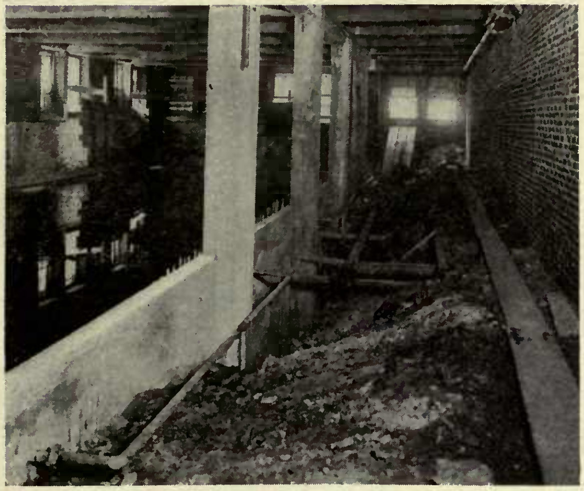
The Truscon Laboratories,
Detroit, Mich.

At Mr. Mackin's request I send you my best indorsement of TRUSCON Waterproofing Paste. We had an almost impossible job successfully treated with this material. Conditions too extreme to go into details. Using nothing else now.

D. P. MARSHALL, Supt.,
Soho Public Baths, City of Pittsburgh



Swimming Pool, Soho Public Baths, Pittsburgh, Pa.
Truscon Waterproofing Paste, *Concentrated,* Remedies a Seemingly Impossible Condition



Swimming Pool, Y. W. C. A. Building, Philadelphia, Pa.

Hewitt & Granger, Architects. Charles Gilpin, General Contractor
Effectively Waterproofed with Truscon Paste, *Concentrated*

CONSTRUCTION SUPERINTENDENT WELL PLEASED

Philadelphia, Pa., July 31, 1915.

The Truscon Laboratories,
Detroit, Mich.

Regarding the use of Truscon Waterproofing Paste in the swimming pool of the Y. W. C. A. Building, would say that I have found it very satisfactory indeed.

The pool is 4 feet deep at the shallow and 9 feet 6 inches at the deep portion. It is 20 feet wide and 60 feet long. The walls are 10 inches thick with a 10 inch bottom. We used a 1:2:4 mix with 24 parts of water to every one part of your Waterproofing Paste.

We stripped the outside of the pool the day after pouring, to allow the air to get to it and to see if there were any voids. In a week, we stripped the inside of the pool and cleaned it thoroughly. We then allowed it to stand for one week. Following this we filled it half full of water, allowing it to stand thus for a week, then filling it to overflow, and leaving the pool standing full of water.

We found the pool absolutely water-tight, with the exception of where the feed water pipes and over-flows passed through the wall. Underneath these pipes, there were several small leaks, caused by shrinkage of the concrete. After pumping the pool, we stopped the leaks by cutting around the pipes about two inches, and taking strings of oakum soaked in Truscon Plaster Bond, and caulking tightly. We then cemented over these places with a 1:1 mix using 18 parts of water to one part of Waterproofing Paste.

I cannot speak too highly of Truscon Waterproofing Paste. If conditions are thoroughly examined, and the Paste used according to directions, an absolutely watertight job will be obtained.

Yours truly,
W. HARVEY, Supt. of Construction.

New Sheeter Building, Charleston, S. C.

Lockwood, Greene & Co., Engineers

Concrete waterproofed with Truscon Waterproofing Paste, *Concentrated*.

R. D. BURNETT CIGAR COMPANY

Birmingham, Ala., June 12, 1913.

The Truscon Laboratories,
Detroit, Mich.

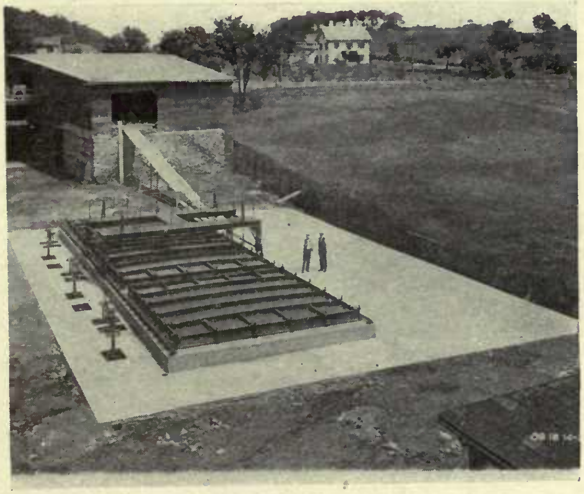
Gentlemen:

Regarding your inquiry as to the results obtained through the waterproofing of the basement in our Wholesale Cigar House, part of which is also used for Retail and Wholesale Piano Store purposes; wish to state that through the directions of the architect for this building, Mr. H. B. Wheelock, this city, we bought of you about 1500 pounds of the TRUSCON Waterproofing Paste, as manufactured by THE TRUSCON LABORATORIES, and used same on the work with the best results. The basement, even after the concrete base of the floor and the concrete walls were poured, was certainly in very bad condition owing to the great amount of water which ran everywhere through the concrete. As I understand, the Waterproofing Paste was used in the 1-inch cement finish of the floors and in the ¾-inch cement coat applied to all the basement walls, and as we had a very competent man direct the application of the cement finish, we were very successful indeed in getting an absolutely watertight job, in spite of the pressure under which the water seemed to come through the concrete previous to the time of applying the cement finish.

Since the work has been completed, about four months ago, we have had some very hot weather, but so far have not had any signs of defective work or defects due to the material in any part of the basement. The goods stored in the basement require absolutely dry storage space as even a slight dampness would affect them seriously, and we can only say that we have no trouble whatever on account of dampness or wet spots in floor or walls.

We, therefore, take occasion to state that we can unhesitatingly recommend the use of this material for waterproofing purposes, under severe conditions, as we certainly had bad conditions before the work was waterproofed and had all kinds of water in the basement. You are at perfect liberty to use this letter in any way that will help you to bring this excellent material before the trade.

Very truly yours,
R. D. BURNETT CIGAR COMPANY,
Per R. D. Burnett, Pres.



Concrete Purifying Tanks, Arlington Gas Light Co., Arlington, Mass.

Tanks made Gas Tight through use of
Trus-Con Waterproofing Paste, *Concentrated*

THE LIGHT, HEAT & POWER CORPORATION

Boston, Mass., August 11, 1914

The Truscon Laboratories,
Detroit, Mich.

Gentlemen:

Regarding your inquiry concerning the results obtained from using Truscon Waterproofing Paste in the reinforced concrete gas purifiers which we built recently for the Arlington Gas Light Company at Arlington, Mass., I beg to state that the paste was applied by the integral method according to your directions, and after the forms were removed the boxes were given a one-inch plaster coat inside. After being completed, these boxes were subjected to an air and gas test of one pound pressure. The concrete in two of the boxes was found to be perfectly gas tight and that of the third had one very slight leak which was stopped immediately after its location.

We are very well satisfied with the results obtained with this Paste and believe it will give satisfaction on any work of similar character.

Yours very truly,
F. E. LEARNED, Mgr.

H. B. NELSON & SONS
Contractors

Muskogee, Okla., June 25, 1914.

The Truscon Laboratories,
Detroit, Mich.

Gentlemen:

In March, 1913, we finished the Agency Hill Reservoir for the City of Muskogee and waterproofed this 6,000,000 gallon reservoir with Truscon Waterproofing Paste. We first used the Waterproofing Paste in the construction of a small tank in which to store water for mixing concrete as the reservoir site was above the reach of city water. This tank we reinforced with woven wire and concrete of 1-2-4 mixture. We used in this the recommended mixture and this tank with three-inch walls was completely waterproof.

In constructing the large reservoir, after removing the forms and while the concrete was yet damp we put upon it a thin coating of cement made up of Waterproofing Paste diluted in water. Upon the floor of the reservoir while green we put on two heavy coats of the Waterproofing (as above mixed). In this way we closed all sand voids and overcame any unevenness in the concrete with very satisfactory results.

Our specifications permitted of not more than five gallons of seepage per minute, but when the test was made by the city for its acceptance there was only one quart seepage. The structure was thoroughly sub-drained with tile around and under the floor and any seepage there was, occurred not through the concrete but at points where the supply and delivery pipes passed through the floor. At any rate at this time, one year after completion, the seepage is practically nothing.

Yours truly,
H. B. NELSON & SONS,
By J. Perwitt Nelson.

Agency Hill Reservoir, Muskogee, Okla.
H. B. Nelson and Sons, Contractors
Effectively Waterproofed with Truscon Waterproofing Paste, *Concentrated*

W. H. SIEVERLING, C. E.
General Contractor

Springfield, Ohio.

The Truscon Laboratories,
Detroit, Mich.

Gentlemen:

Regarding the waterproofing you furnished for the Springfield Light, Heat & Power Co.'s new consolidated power-house, will say that nearly two tons of "TRUSCON Waterproofing Paste" were used.

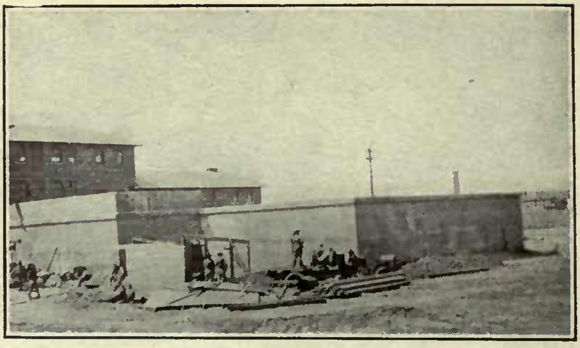
The situation seemed hopeless, as I had not only to contend with numerous living springs, flowing through the power plant, coming up from the fissures and seams of limestone cliffs out of which the foundations were blasted, but also high waters from a turbulent creek, flowing by the plant. I had as much as eight (8) feet of water in the basements about all last winter and spring.

After much pumping and building of sheep troughs and sumps, and using plenty of TRUSCON Waterproofing Paste incorporated into the concrete for walls, floors and top coat, I succeeded in getting a perfectly dry basement for their electrical machinery.

I like to use TRUSCON Paste, because with the average common labor you can get, it is easier to use and get results than with any other waterproofing that requires intelligent, if not expert, manipulation.

I can assure you that the Light Company is more than satisfied, as we have had some high waters since, and everything proved watertight.

Very truly,
W. H. SIEVERLING.



Iron Removal and Filtration Plant, Camp Funston, Kansas

Basins and all concrete walls and floors coming in contact with water waterproofed with Truscon Waterproofing Paste, *Concentrated,* Capacity of Plant, three million gallons per day. Plant built under direction of Major W. L. Benham, Construction Quartermaster, Lieut. H. W. Nighswonger, Supervising Engineer of Construction

JAMES KENNEDY CONSTRUCTION COMPANY

The Truscon Laboratories,
Detroit, Mich.

Portland, Oregon, Feb. 9, 1915.

Replying to your inquiry with reference to our use of Truscon Waterproofing material. We used your material last year in the construction of six reservoirs: Two at Linnton, two at Willbridge, and two at Whitwood Court. The Waterproofing proved to be satisfactory in every way, as the city test showed no leaks through the concrete. The engineer on this work was Mr. L. C. Kelsey, Selling Building, Portland, Oregon. He can certify to the truth of this statement, as he was present and in charge of the city when the tests were made.

Yours truly,
JAMES KENNEDY CONSTRUCTION CO.
By J. D. Hanley.

THE FAIRMONT CREAMERY COMPANY

The Truscon Laboratories,
Detroit, Mich.

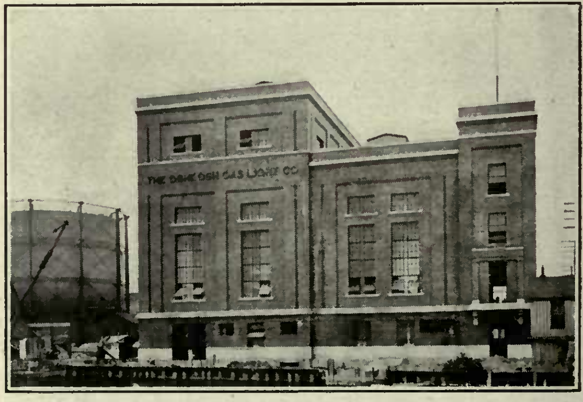
May 1st, 1914.

Referring to your inquiry as to whether we were pleased with Truscon Waterproofing Paste Concentrated which we used on all floors of our new building in Columbus, where water was freely used, will say that we found it very satisfactory.

We put six inches of concrete and one inch of topping on these floors and we used the Paste in both. We have never had any trouble with the water soaking through, and in fact we are so well pleased with this material that we used it on some concrete floors which were placed upon wooden floors in a building we fitted up for a creamery at Buffalo, N. Y. So far, in the latter building, we have seen no leaks through this material.

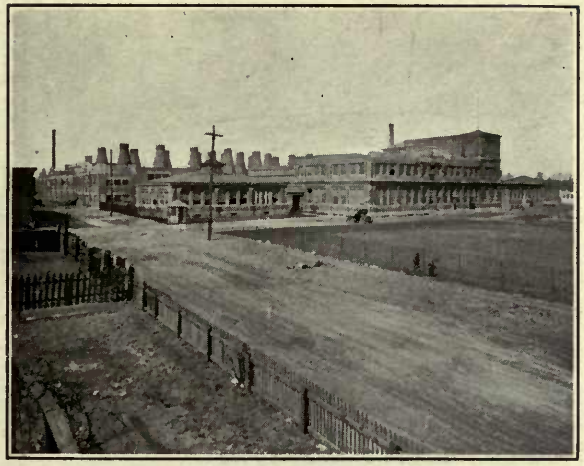
As far as we can see, and we have given it an eight months' test in Columbus, this material gives perfect satisfaction.

Yours truly,
THE FAIRMONT CREAMERY COMPANY,
By M. H. Bennett, Construction Manager



New Electric Plant of Oshkosh Gas Company, Oshkosh, Wis.
Wm. A. Baehr, Chief Consulting and Constructing Engineer

Truscon Waterproofing Paste used in Crusher and Water Softening pits, 14 ft. head of water.



Factory of the Abrasive Co., Bridesburg, Pa.
Horace W. Castor, Architect
John R. Wiggins Co., Inc., General Contractors

Pits under grinding machines waterproofed with Truscon Waterproofing Paste, *Concentrated.* Absolute dryness essential in these pits.

BICKS & KLUNPP

The Truscon Laboratories, Decatur, Ill.
Detroit, Mich.
Gentlemen:

We are in the concrete business, and are making burial vaults. We are told that if we used ——— Waterproofing Powder we could make these vaults waterproof, but we find by filling the vaults with water, that they leak like sieves, and that the waterproofing powder comes up to the top as the concrete is pored. After the vaults have set, you can scrape the powder off with your finger, and it leaves the concrete full of soft places.

We do not care to risk any more labor or material with powder waterproofing, but want you to send us prices on your Waterproofing Paste. We have poured a box about 12 inches square, using TRUSCON Waterproofing Paste, and upon filling same with water, note that the outside keeps perfectly dry. In using the powder waterproofing, we gave the same careful attention to the mixing. We first mixed the cement and waterproofing compound through a fine sieve, and made sure that the dry mixture was perfectly uniform.

Very truly yours,
BICKS & KLUNPP.

BATES MANUFACTURING CO.

The Truscon Laboratories, Lewiston, Maine,
Detroit, Mich.
Gentlemen:

Your telegram of today received. We used 53 barrels of TRUSCON Waterproofing Paste to waterproof concrete walls and floors of turbine chambers, forebay and tailrace of hydraulic power plant. Present conditions indicate perfect success.

Very respectfully,
BATES MANUFACTURING CO.

New Orleans Country Club, New Orleans, La.
Favrot & Livaudais, Architects

Truscon Waterproofing Paste, *Concentrated*, used in basements and on all floors.

F. B. HATCH
Contractor and Builder

San Juan, Porto Rico.

Messrs. Behn Bros., San Juan, P. R.
Gentlemen:

I take pleasure in stating that I have used your TRUSCON Waterproofing Paste on several pumping pits where they had very severe test and will say that I am highly pleased with it. It is the best waterproofing for mixing with concrete that I have yet found.

Yours very truly,
F. B. HATCH.

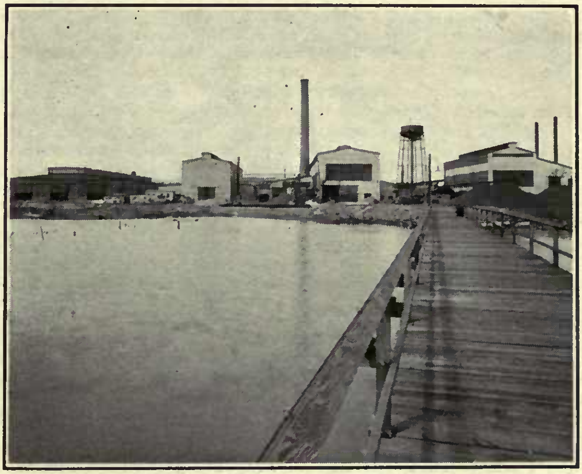
WAUKESHA CONCRETE BLOCK & MATERIAL CO.

Waukesha, Wis.

The Truscon Laboratories,
Detroit, Mich.

We believe your TRUSCON Waterproofing Paste to be superior to other preparations we have used.

Very truly,
WAUKESHA CON. BLOCK & MAT. CO.



Tacony Ordnance Co., Tacony, Pa.
W. F. Mark Const. Co., General Contractors

Basements of all buildings waterproofed with Truscon Waterproofing Paste, *Concentrated.* Water in the foreground is the Delaware River which at this point has a tide of five feet; basements are well under water at high tide.

PACIFIC ELECTRIC ENGINEERING COMPANY

Portland, Oregon.

The Truscon Laboratories,
Detroit, Mich.

In answer to your inquiry of recent date, we beg to say that we used eighty gallons of TRUSCON Waterproofing Paste last February in the floors and walls of the machinery pit of the power house, erected by us at Oswego for the Oregon Iron and Steel Co.

After the pit walls were completed and before the cement had time to fairly set, an accident occurred at the headgates which caused the water to stand in the pit about three feet deep for a week. During this time the walls showed no leakage and we are thoroughly convinced that you have an article that will waterproof any cement that it is applied to.

Should we need any in the future you may rest assured that you will hear from us.

Yours very truly,
PACIFIC ELECTRIC ENGINEERING CO.

GLENMORE DISTILLERIES COMPANY

Owensboro, Ky.

The Truscon Laboratories,
Detroit, Mich.
Gentlemen:

Regarding the use of TRUSCON Waterproofing Paste for the construction of tanks and cisterns, we are pleased to advise that last summer we constructed a beer well 16 feet in diameter by 12 feet deep, using a 1-2-4 mix of washed gravel concrete, and mixing this with TRUSCON Waterproofing Paste as per your standard specifications.

Two days after this beer well was poured it was surrounded with water to within one foot of the top, but so far we have yet to see the slightest sign of seepage, and it is apparently absolutely water-tight.

Yours very truly,
GLENMORE DISTILLERIES COMPANY,
By H. S. Barton, V. P. and Gen. Mgr.

THE LEHIGH COAL & NAVIGATION CO.

Bangor, Maine

Bangor, Me., October 23, 1913.

Messrs. N. H. Bragg & Sons,
City.

Gentlemen:

I have refrained from reporting the results of our waterproofing until the TRUSCON work had adequate water-resisting tests. The last three weeks of rain have afforded us satisfactory demonstration of the goodness of TRUSCON.

Our pocket is erected over a tunnel, about 150 x 8 x 8, and beneath the tunnel is a subterranean river, icy-cold, with swift current. At far end of tunnel, a ledge retarded egress of water, down the general gently sloping tract on which the pocket is built. The tunnel was well built, the action of the river, and boiling springs nearly broke its back, despite the several thousand tons of dead-weight. The floor and both sides of the tunnel opened, and through the fissures poured the water, at times. An endless carrier with several hundred balancing buckets runs in the tunnel through ends and across top of pocket.

Frequently, upon starting work for the day, and particularly in winter, we would find a seepage during the night of about 30,000 to 35,000 gallons of crystal, cold water in the tunnel submerging the buckets. In zero weather, the attendant ice was costly and annoying, to put it mildly.

The combined efforts of rotary pump and six-inch drain leading from far end of tunnel failed to carry off the water at all times.

We had the tunnel waterproofed two years ago, and for a time it held. Although at no time did this repaired tunnel have so long a siege of rain, feeding the river and springs, it eventually broke under strain less severe than to which subjected since October 1.

Finally, we evolved a new plan.

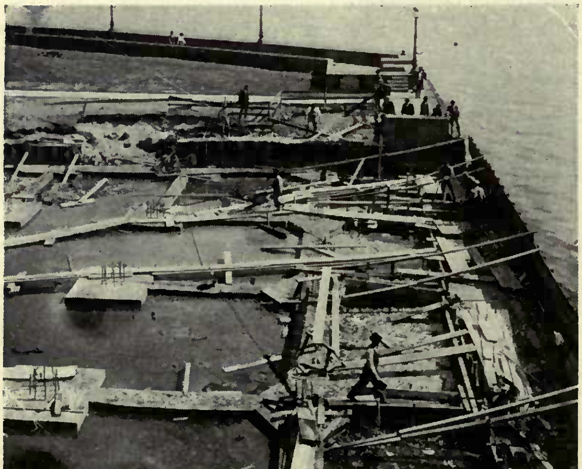
We dug auxiliary side drains, giving total drainage length of about 3,000 feet, blasted the ledge, and then having, as we believe, diverted the water in a measure, we followed your TRUSCON book to the letter, and used that wonderful compound in repairing and waterproofing the great fissures in our heavy concrete tunnel floor and walls.

The work was performed under great difficulties, as water constantly was bubbling up in the tunnel, although diminished in a measure by the new drains. The concrete mixture with TRUSCON in it hardened in the water, and it was remarkable to note its stiffening propensities under circumstances that would simply wash away ordinary concrete as fast as placed in position.

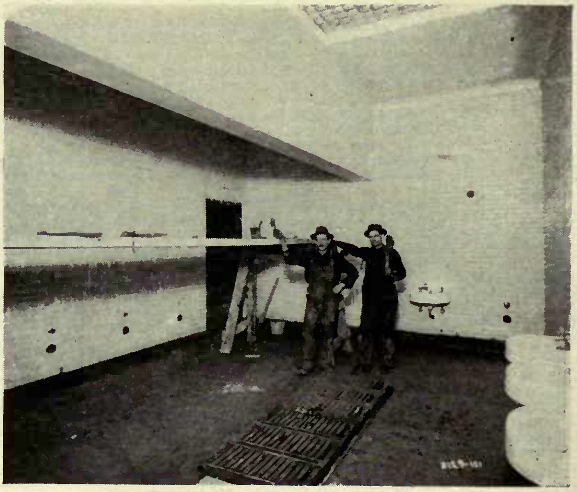
TRUSCON, we believe, has solved our costly, vexatious and at times baffling problem. I might add that the cost of the waterproofing did not exceed $25, although several thousands had been expended previously in the attempt to overcome the trouble. We will gladly impart personal information, and exhibit the work to any others annoyed by similar troubles, and show them how to overcome them with TRUSCON Waterproofing Paste, *Concentrated*, properly applied.

Very truly yours,

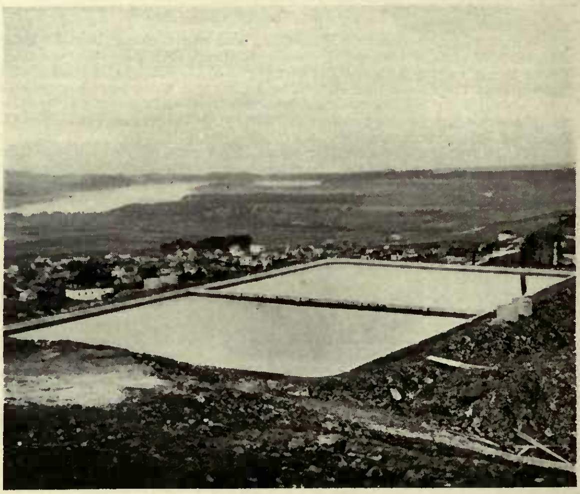
J. McLEOD, Agent.



The Gowan-Lenning-Brown Building, Duluth, Minn.
F. G. German, Architect. Leif Jenssen, Assistant Architect
W. J. Zitterell, Contractor
Basements Waterproofed against heavy hydrostatic pressure with Truscon Waterproofing Paste, *Concentrated*



Smithfield Street Public Comfort Station, Pittsburgh, Pa.
J. P. Brennan, Architect
Truscon Waterproofing Paste, *Concentrated*, used throughout all Concrete



Municipal Reservoir, Daly City, Cal.
F. C. Roberts, Engineer. Tieslau Bros., Contractors
Waterproofed with Truscon Waterproofing Paste, *Concentrated*, in accordance with Waterproofed Cement Plaster Coat proceess

HARDY & ARONS

Dayton, Ohio

The Truscon Laboratories,
Detroit, Mich.

Gentlemen:

Ever since the erection of the Colonial Building, corner of Third and Grimes streets, the basement has been useless because of the great seepage of water through the walls and cement floor.

We contracted with the Dayton Fiber Plaster Co., of this city, to make this basement watertight and dampproof with your products. They applied a ¾-inch coating of cement mortar on these walls and a 2-inch cement floor, using your Waterproofing Paste in the water with which the material was mixed. The surface thus treated amounted to about 10,000 square feet. Our basement is now absolutely dry, and we cannot too highly recommend your products.

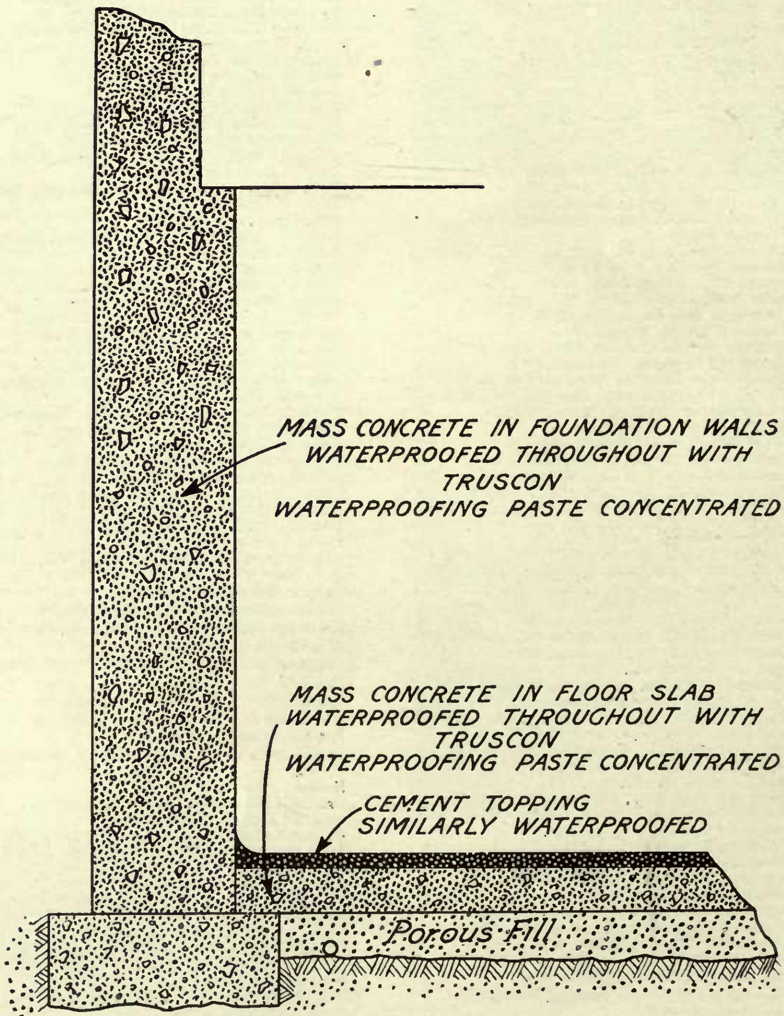
Respectfully yours,

HARDY & ARONS.

A Few Representative Users of Truscon Waterproofing Paste, *Concentrated*

St. Louis South-Western Ry.
Albion Shale Brick Co., Albion, Ill.
Old Crow Distillery, Glenn Creek, Ky.
Packard Motor Car Co., Detroit and Philadelphia.
Medical College, Charleston, S. C.
Western Sugar Refining Co., San Francisco.
Ford Service Buildings—
- Cincinnati.
- Louisville.
- Indianapolis.
- Atlanta.
- Dallas.
- New York City.
- Philadelphia.
- Detroit.
- Minneapolis.

Bates Mfg. Co., Lewiston, Me.
Oliver Chilled Plow Co., South Bend, Ind.
Stroh Brewing Company, Detroit, Mich.
Edison Illuminating Co., Detroit, Mich.
Pittsburgh Comfort Station, Pittsburgh, Pa.
Arlington Gas Co.
City Reservoir, Daly, Cal.
Atchison, Topeka & Santa Fe Ry.
Kresge Bldg., Detroit, Mich.
Hotel Statler, Detroit, Mich.
Lever Bros. Soap Co., Boston, Mass.
Thomas A. Edison, Newark, N. J.
Goodyear Rubber Company, Akron, Ohio.
Agency Hill Reservoir, Muskogee, Okla.
Grand Central Terminal, New York City, N. Y.
Hawley & Hoops Company, New York City, N. Y.
Revere Rubber Company, Chelsea, Mass.
Bath Iron Works, Bath, Maine.
Lozier Motor Car Co., Detroit, Mich.
Hudson Motor Car Co., Detroit, Mich.
Gramm Motor Car Co., Lima, Ohio.
City Reservoir, St. Charles, Mo.
City Reservoir, Hancock, Mich.
City Reservoir, Asheville, N. C.
City Reservoir, Lafayette, Ind.
Lighting Plant, Springfield, Ohio.
Mexican Light & Power Co., Mexico City, Mexico.
Westinghouse Lamp Factory, Watsessing, N. J.
Grain Elevator, Fort Worth, Texas.
General Electric Co., Schenectady, N. Y.,
Goldfield Milling & Transportation Co., Goldfield, Nev.
Rogers-Brown Ore Co., Deerwood, Minn.
Markham Air Rifle Co., Plymouth, Mich.
Seaboard Airline Ry., Portsmouth, Va.
Beckett Paper Co., Hamilton, Ohio.
Western Electric Co., New York City, and elsewhere.
Inter-Ocean Steel Co., Chicago, Ill.
Jefferson Powder Co., Birmingham, Ala.
Chicago, Rock Island & Southern Ry.
Magee Theatre, Schenectady, N. Y.
Hartman Furniture Co., Warehouse, Chicago, Ill.
Beckwith Stove Plant, Dowagiac, Mich.
Anderson Forge Co., Detroit, Mich.
Armstrong Tannery, Detroit, Mich.
Wissmath Packing Co., Fort Madison, Ia.
Quartermaster's Department, Washington, D. C.
Kling Brewery, Detroit, Mich.
Capitol City Brewery, Montgomery, Ala.
Great Lakes Engineering Co., Ashtabula, Ohio.
Brunett Falls Mfg. Co., Cornell, Wis.
Continental Motor Mfg. Co., Detroit, Mich.
Central Market Building, Detroit, Mich.
Government Light House Caissons, Detroit River
Pere Marquette R. R.
Grand Rapids & Indiana R. R.
Edward Ford Plate Glass Co., Rossford, Ohio.
Detroit Free Press Building, Detroit, Mich.
Shepard Building, Chicago, Ill.
Press Building, Pittsburgh, Pa.
Oil Well Supply Building, Pittsburgh, Pa.
Hamburger Building, Pittsburgh, Pa.
Y. M. C. A., Butler, Pa.
Y. M. C. A. Building, Greensburg, Pa.
Y. M. C. A. Building, New Castle, Pa.
Y. M. C. A. Swimming Pool, Red Wing, Minn.
Y. M. C. A. Swimming Pool, Fostoria, Ohio.
Y. M. C. A. Swimming Pool, St. Joseph, Mo.
Y. M. C. A. Swimming Pool, Burnham. Pa.
E. I. DuPont DeNemours Co., Wilmington, Del.
M. H. McCloskey, Jr., 1620 Thompson St., Philadelphia, Pa.
Clifton Mfg. Co., Waco, Texas.
Jones & McLaughlin Steel Co., Pittsburgh, Pa.
Spelts Grain Co., Sterling, Col.
Estate of Charles M. Schwab, Loretto Road, Pa.
A. G. Kiser, Contractor and Builder, Tazewell, Va.
Ivy White Ash Coal Co., Ivaton, W. Va.
Georges Creek Coal Co., Inc., Setzel, Logan Co., W. Va.
John Griffiths & Son Co., 1011 Merchants Loan & Trust Bldg., Chicago, Ill.
The Gun Pits placed on lower Delaware River by U. S. Government.
Vacuum Oil Co., Paulsboro, N. J.
Houston Collieries Co., Maitland, W. Va.
Tug River Power Co., Welch, W. Va.
Keystone Coal & Coke Co., Keystone, W. Va.
McDowell Coal & Coke Co., McDowell, W. Va.
Pennsylvania Rubber Co., Jeannette, Pa.
Burroughs Adding Machine Co., Detroit, Mich.
Cadillac Motor Car Co., Detroit, Mich.
Swift & Company, South Omaha and Cambridge.
Boston & Maine Railway.
Dodge Bros., Detroit, Mich.
Sellwood Park Swimming Pool, Portland, Ore.
Water Tank, Cojimar, Cuba.
Cook Brewing Co., Evansville, Ind.
Frick & Lindsay Building, Pittsburgh, Pa.
Heider Manufacturing Co., Carroll, Iowa.
The Mission Conception, San Antonio, Texas.
Los Angeles Brewing Co., Los Angeles, Calif.
Sparta Gas & Electric Co., Sparta, Ill.
Jacksonville Concrete Co., Jacksonville, Fla.
Stitzer Engineering & Contracting Co., Philadelphia.
Turner & Stewart, Camden, N. J.
McClintic-Marshall Construction Co., Pottstown, Pa.
Atlantic City Gas Company, Atlantic City, N. J.
Bright & Co., Hazelton, Pa.
R. D. Burnett Building, Birmingham, Ala.
U. S. Glass Company, Butler, Pa.
Butler Concrete & Plaster Co., Butler, Pa.
Standard Steel Car Co., Butler, Pa.
10th Reg. Armory, Monongahela, Pa.
Moose Temple, Monnessen, Pa.
U. S. Government Experimental Mine, Wallace Sta., Pa.
U. P. Church, Erie, Pa.
St. Pius Church, McKeesport, Pa.
Duquesne Parochial Schools, Duquesne, Pa.
Pittsburgh Water Heater Co., Idlewood, Pa.
Boggs Building, Pittsburgh, Pa.
Crafton High School, Crafton, Pa.
P. & L. E. Ry.
Keystone Coal & Coke Co., Greensburg, Pa.
New Castle Dry Goods Co., New Castle, Pa.
Pittsburgh Coal Co., Pittsburgh, Pa.
Monongahela Saw & Planing Mill Co., Monongahela. Pa.
Northern Power Co., Potsdam, N. Y.
Caledonia Milling Co., Caledonia, Mich.
Henahan King Co., Toledo, Ohio.
Columbus Machine & Tool Co., Columbus, Ohio.
J. M. Wagenheim & Son, Newark, Ohio.
Herman Gundlach, Houghton, Mich.
Thomas Culinan, Providence, R. I.
Ottaray Canning Co., Ltd., Henderson, N. C.
Wayne County Farm, Eloise, Mich.
Stark Brewing Company, Canton, Ohio.
Penn Mining Co., Vulcan, Mich.
Ledbetter Manufacturing Co., Rockingham, N. C.
Morgan Engineering Co., Alliance, Ohio.
Rubber Regenerating Co., Mishawaka, Ind.
Prestolite Co., Indianapolis, Ind.
Sterling Silk Glove Co., Bangor, Pa.
Adam E. Ferguson Creamery, Lansing, Mich.
Consolidated Gas, Electric Light & Power Co., Baltimore, Md.
Bedford Foundry & Machine Co., Bedford, Ind.
Thomas Brothers, Moosejaw, Sask.
Plymouth Milling Co., Plymouth, Mich.
International Time Recording Co., Endicott, N. Y.
Dr. C. E. Schmitz, Cambridge, Idaho.
First National Bank, Lestershire, N. Y.
Fonnesbeck Knitting Co., Ogden, Utah.
Cheboygan Manufacturing Co., Cheboygan, Mich.
U. S. Gun Pits on the Delaware River.
E. I. Dupont de Nemours & Co., Deep Water Plant, Carney's Point, N. J.
Penn. Harris Hotel, Harrisburg, Penna.
Penna. Ry. Co.
Philadelphia & Reading Ry. Co.
Swimming Pools, City of Philadelphia.



Waterproofing mass concrete by integral method.

Specification for Waterproofing Mass Concrete by Integral Method

Applicable to Standpipes, Cisterns, Reservoirs, Foundations and Similar Structures

1. Intent—It is the intent of these specifications to obtain a water-tight concrete structure.

2. Method—Water-tightness shall be secured by the addition of TRUSCON Waterproofing Paste, *Concentrated,* as manufactured by THE TRUSCON LABORATORIES, Detroit, Michigan, to all water used to temper the dry mixture of cement and aggregate, in proportions and mixed as directed below.

3. Ingredients and Proportions for Concrete—The concrete composing the main body of the structure shall consist of one (1) part cement, two (2) parts of sand, and four (4) parts of stone, each to meet the following requirements:

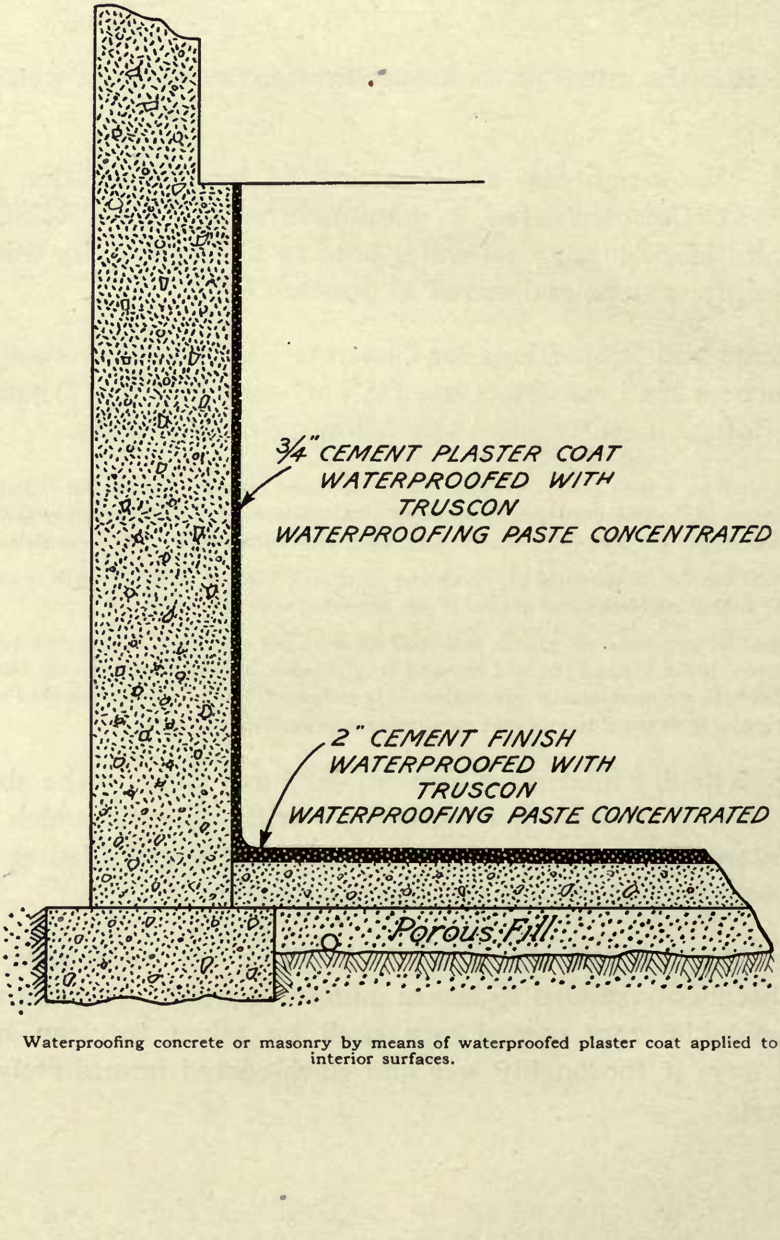
(a) The cement shall be a high grade Portland, which has been carefully tested and found to satisfactorily pass the requirements of the Standard Specifications of The American Society for Testing Materials, and preferably ground so that eighty per cent (80%) shall pass a standard two-hundred (200) mesh sieve.

(b) The sand shall consist of spherical grains of any hard rock that is practically free from clay, absolutely free from organic matter, and uniformly graded in size from coarse to fine.

(c) The stone shall be screened from gravel, and shall for sixty per cent (60%) of its bulk be uniformly graded between diameters of one (1) and one and one-half (1½") inches, and for forty per cent (40%) of its bulk be uniformly graded between diameters of one quarter (¼) and one (1) inch. A hard crushed trap rock may be substituted for gravel if screened to meet the requirements indicated.

4. Mixing—The dry mixture of cement, sand and stone in the above proportions shall be tempered to a medium wet consistency with water to which one (1) part of TRUSCON Waterproofing Paste, *Concentrated,* has been added as directed by the manufacturers, for every thirty-six (36) parts of water.

5. Placing—All the concrete shall be placed in one continuous operation, each pouring being thoroughly spaded to insure uniform density. In cases where joints are absolutely unavoidable, very special care shall be taken to clean and roughen the old surface and have it thoroughly wet and slush-coated immediately before placing additional concrete.



Waterproofing concrete or masonry by means of waterproofed plaster coat applied to interior surfaces.

Specifications for Waterproofing Concrete and General Masonry Structures by Means of Waterproofed Plaster Coat

Applicable to Cisterns, Reservoirs, Foundations, Basements, Tunnels, Subways and Similar Structures

1. Intent—It is the intent of these specifications to obtain a water-tight structure.

2. Method—Water-tightness shall be secured by plastering the interior surface of the structure with a continuous coat of Portland cement mortar waterproofed with TRUSCON Waterproofing Paste, *Concentrated,* as manufactured by THE TRUSCON LABORATORIES, Detroit, Michigan.

3. Ingredients and Proportions of Waterproofed Plaster Coat—The mortar composing the plaster coat shall consist of one (1) part of cement and two (2) parts of sand, to meet the following requirements:

(a) The cement shall be a high grade Portland, which has been carefully tested and found to satisfactorily meet the requirements of the Standard Specifications of the American Society for Testing Materials and preferably ground so that eighty per cent (80%) shall pass a standard two hundred (200) mesh sieve.

(b) The sand shall consist of spherical grains of any hard rock that is practically free from clay, absolutely free from organic matter, and uniformly graded in size from coarse to fine.

4. Preparation of the Coating—The waterproofed cement mortar shall be prepared by thoroughly tempering (to required consistency) a dry mixture of one (1) part of cement and two (2) parts of sand, with water to which TRUSCON Waterproofing Paste, *Concentrated,* has been added in the proportion of one (1) part of Paste to eighteen (18) parts of water, as directed by the manufacturers.

5. Preparation of Surface to be Coated—Before plastering the cement mortar on the hardened concrete, the surface of same shall be treated as indicated in the following:

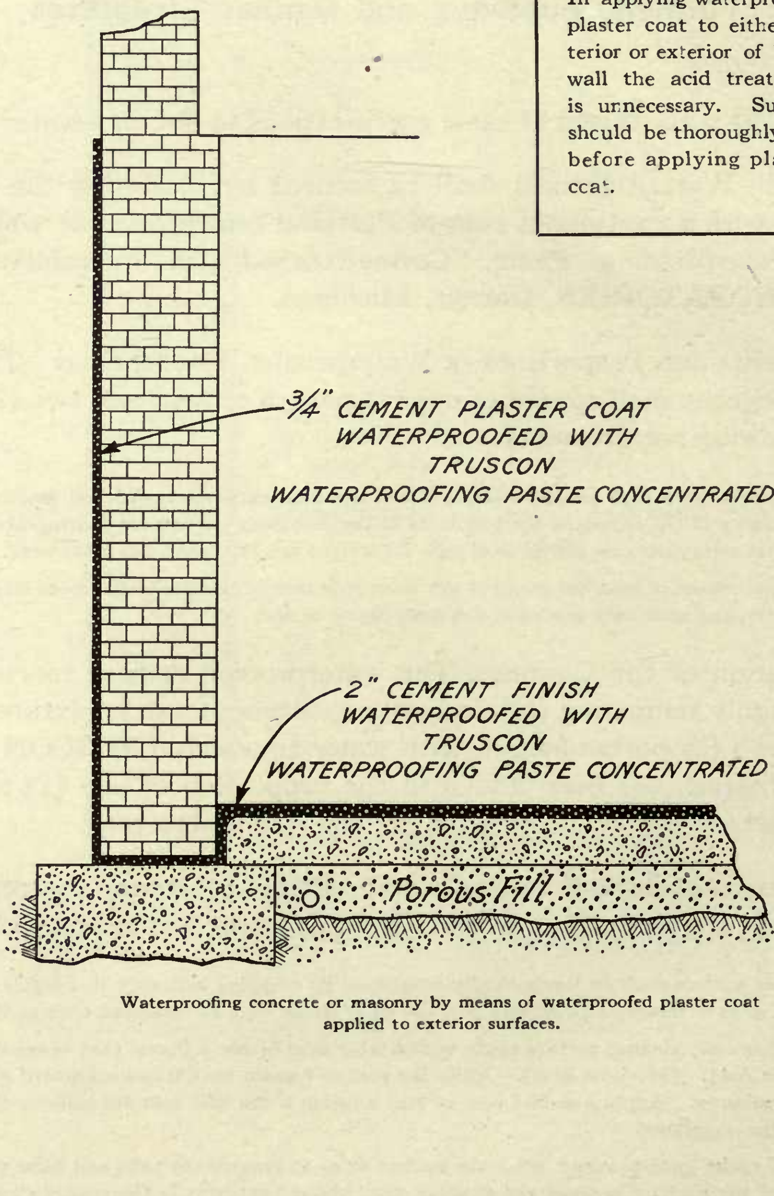
(a) The hardened surface shall be mechanically roughened by chipping and very thoroughly cleaned with a heavy wire broom, so as to remove all dust and dirt. A jet of steam shall be employed to clean the wall, if available.

(b) To the mechanically cleaned surface apply with a large acid brush, a liberal ccat of one to ten (1:10) solution of Hydrochloric Acid. (Muriatic Acid). Allow the acid to remain until it has exhausted itself, which will require at least ten minutes. Apply a second coat of acid solution if the first does not sufficiently clean and expose the surface of the aggregate.

(c) With a hose under good pressure, slush the surface so as to remove the salts and locse particles resulting from the action of the acid. Continue the slushing until the old ccncrete is thoroughly cleaned and soaked to its full hydrometric capacity. Thoroughly wire-brush the surface so as to remove the particles which have been loosened by the action of the acid.

(d) To the cleaned saturated surface apply with a strong fibre brush a coating of pure cement mixed to a thick, creamy consistency with water to which TRUSCON Waterproofing Paste, *Concentrated,* has been added in the proportion of one (1) part of Paste to eighteen (18) parts of water. Rub in vigorously so as to fill all crevices and cavities produced by the action of the acid.

In applying waterproofed plaster coat to either interior or exterior of brick wall the acid treatment is unnecessary. Surface should be thoroughly wet before applying plaster coat.



Waterproofing concrete or masonry by means of waterproofed plaster coat applied to exterior surfaces.

6. Application of Coating to Sides—Immediately after applying the slush coat, the first coat of waterproofed cement mortar shall be applied to a thickness of three-eighths of an inch (3/8″) directly on the slush coat, and well troweled and rubbed into the crevices of the surface. This first coat shall be lightly scratched before showing initial set. Before this first coat has reached its final set, the second coat shall be applied, of equal thickness, so as to give a full average thickness of three-quarters of an inch (3/4″). Most special care shall be exercised to apply this finish coat before the first coat has reached its final set. The finish coat shall be thoroughly floated to an even surface and subsequently troweled free from any porous imperfections.

7. Floor Coating—The floors shall be prepared and treated exactly as indicated above, and finished with a waterproof cement mortar to a thickness of two inches (2″). Special care should be exercised to bond the wall coating to the floor coating, so as to make the waterproofed coating continuous over the entire surface.

8. Pressure—Where water is running through the wall, proper drainage must be provided by drilling holes and inserting tubes in the wall, to concentrate the flow of water. With the pressure relieved, the waterproofed plaster coat shall be applied to the drained portions of the wall. The drainage pipes shall remain open until the waterproofed plaster coat has thoroughly set and is capable of resisting the pressure of its own adhesive strength, when the drainage pipes shall be closed with suitable plugs and overcoated with the waterproofed cement mortar.

9. Inspection—When hardened, the waterproofed plaster coat shall be sounded with a light hammer and all loose and defective plaster shall be cut out and replaced.

Specifications for Waterproofing Cement Stucco

1. Intent—It is the intent of these specifications to obtain a sound, permanent and waterproof stucco.

2. Materials—The materials composing the stucco shall consist of:

(a) Portland cement which has been carefully tested and found to satisfactorily meet the requirements of the Specifications of the American Society for Testing Materials.

(b) Sand which is practically free from organic matter and uniformly graded in size from coarse to fine.

(c) Hydrated lime that is uniform in quality and perfectly hydrated.

(d) TRUSCON Waterproofing Paste, *Concentrated,* as manufactured by THE TRUSCON LABORATORIES, Detroit, Michigan.

3. Proportions—The proportions of the above specified materials by volume, shall be five (5) parts of cement, twelve (12) parts of sand, and one (1) part of hydrated lime. One (1) part of TRUSCON Waterproofing Paste, *Concentrated,* shall be added to every eighteen (18) parts of water used to temper the mortar.

4. Mixing—The cement and hydrated lime, after being thoroughly mixed dry to uniform color, shall be added to the dry sand and the whole manipulated until evenly mixed. The dry mixture shall then be tempered to the correct working consistency with water to which TRUSCON Waterproofing Paste, *Concentrated,* has been added in proportion specified. The mortar must be thoroughly worked until perfectly homogeneous. This composition shall only be made up in lots that can be immediately applied, and any material that has been mixed with water over thirty (30) minutes before applying shall be rejected.

5. Application—All walls shown on elevation for stucco finish shall be two-coat work. The first coat shall be prepared as specified above, with the addition of long cow hair for keying when applied to metal lath. The face of the first coat shall be thoroughly scratched over to form a key for the finish coat, which shall be applied to a total thickness of one inch (1″), when the first coat has set sufficiently hard to safely hold it. The finish coat shall be carefully floated from any porous imperfections.

When plastering over a masonry surface, special care must be taken to thoroughly saturate the masonry with water and the plaster applied at once.

6. Drying—Special care shall be taken to avoid too rapid drying. If in direct rays of the sun, the stucco shall be protected with a damp canvas or burlap, and when sufficiently resistant, shall be frequently sprinkled with water.

7. No exterior plastering shall be permitted until all interior partitions are studded up and completely braced.

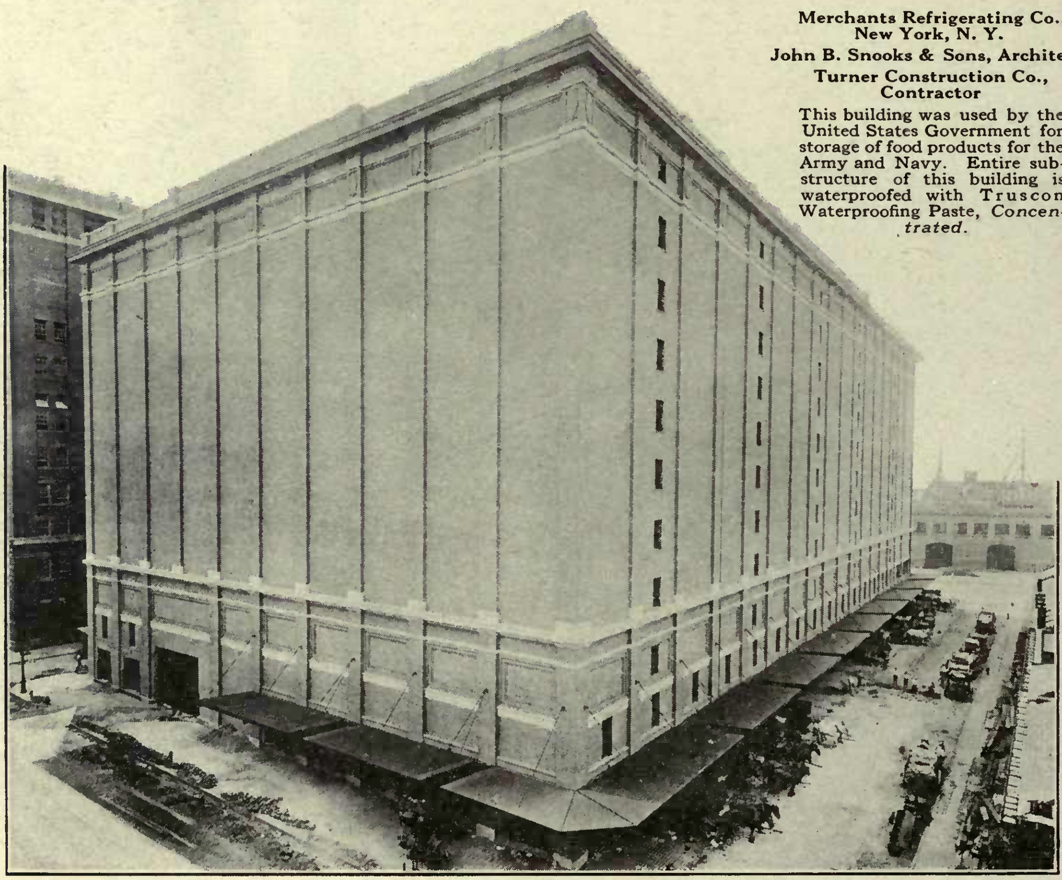
PART III

A Few More Representative Building Operations Where Truscon Waterproofing Paste, *Concentrated* Has Been Used

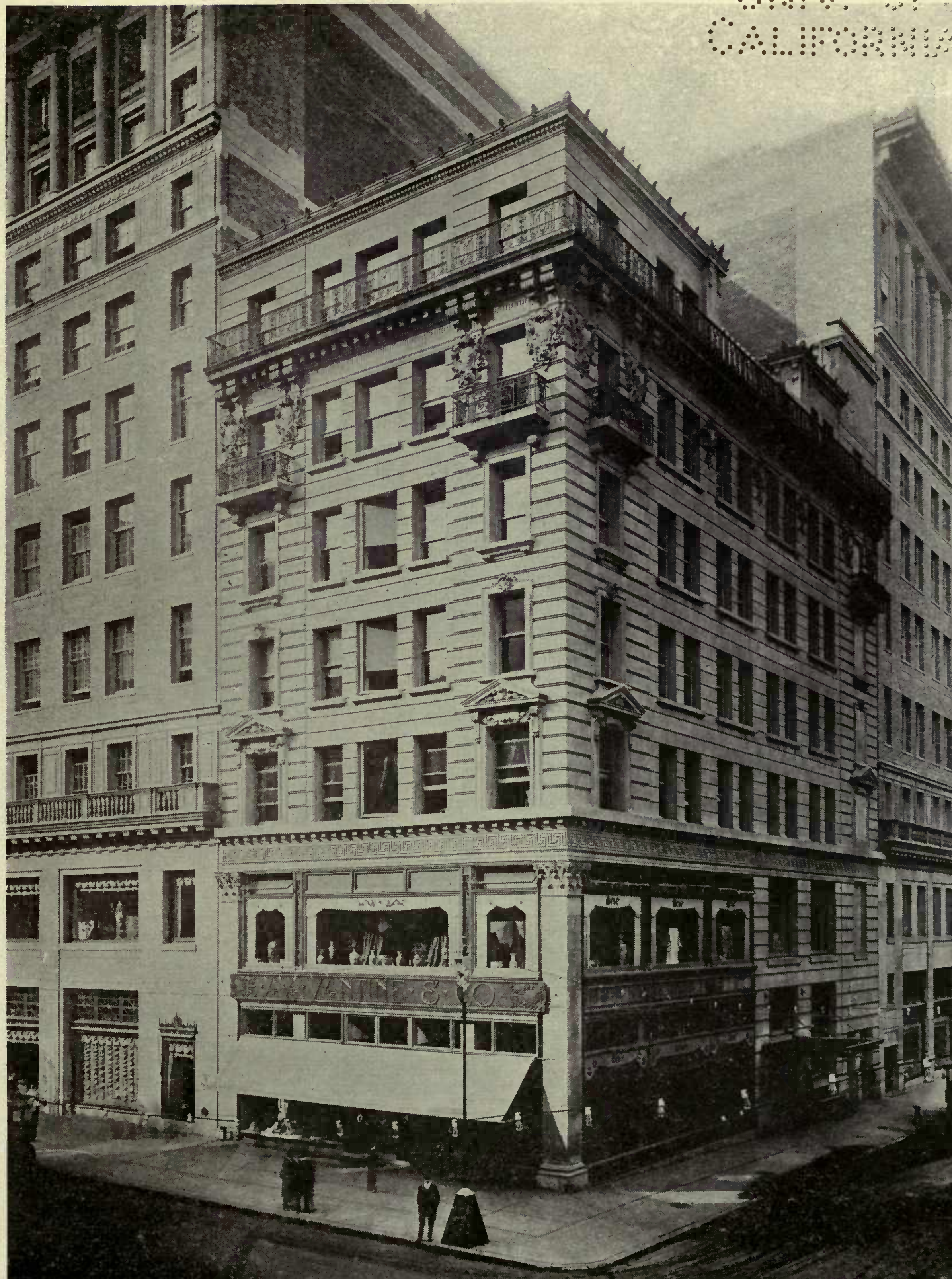
Victor Talking Machine Co., Camden, N. J. Ballinger & Perrot, Architects. Irwin & Leighton General Contractors

This building is located near the Delaware River, the basement of the working establishment being some five or six feet below high tide. Foundation work waterproofed with Truscon Waterproofing Paste, *Concentrated.*

Carter, Carter & Meiggs Building, Boston, Mass.
Densmore & Le Clear, Architects,
George A. Fuller Co., Contractors
Basement waterproofed against heavy tide water pressure with Truscon Waterproofing Paste, *Concentrated*.



Merchants Refrigerating Co., New York, N. Y.
John B. Snooks & Sons, Architects
Turner Construction Co., Contractor
This building was used by the United States Government for storage of food products for the Army and Navy. Entire substructure of this building is waterproofed with Truscon Waterproofing Paste, *Concentrated*.

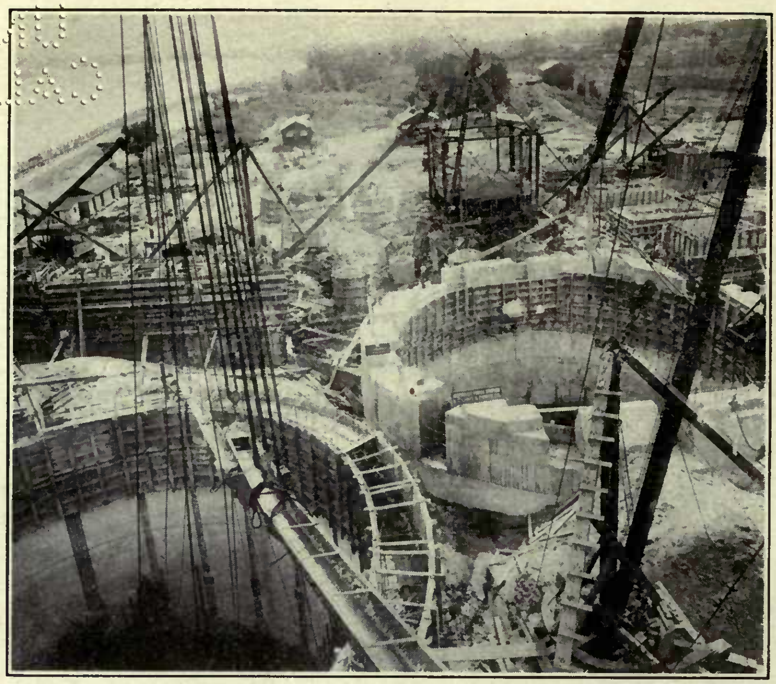


Van Tine Building, New York, N. Y.
Basement waterproofed with Truscon Waterproofing Paste, *Concentrated*.

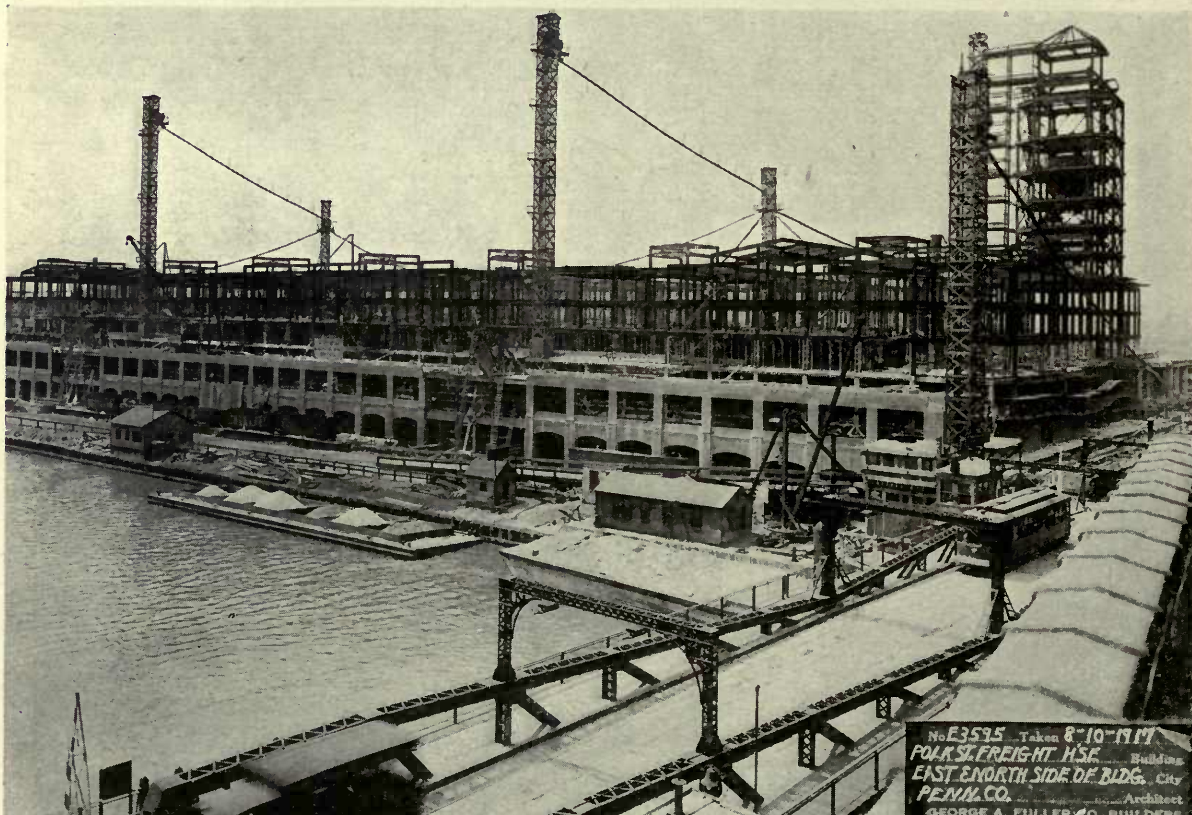
Residence of James Deering, Miami, Florida
F. Burrall Hoffman Jr., and Paul Chalfin, Associate Architects; John B. Orr, Stucco Contractor
Stucco Waterproofed Throughout with Truscon Waterproofing Paste, *Concentrated*

Detroit News Building, Detroit, Michigan. Albert Kahn, Architect, Ernest Wilby, Associate
Truscon Waterproofing Paste, *Concentrated,* used in all foundation work.

Rogers Peet Building, New York, N. Y. Townsend, Steinle & Haskell, Architects
Basement waterproofed with Truscon Waterproofing Paste, *Concentrated.*



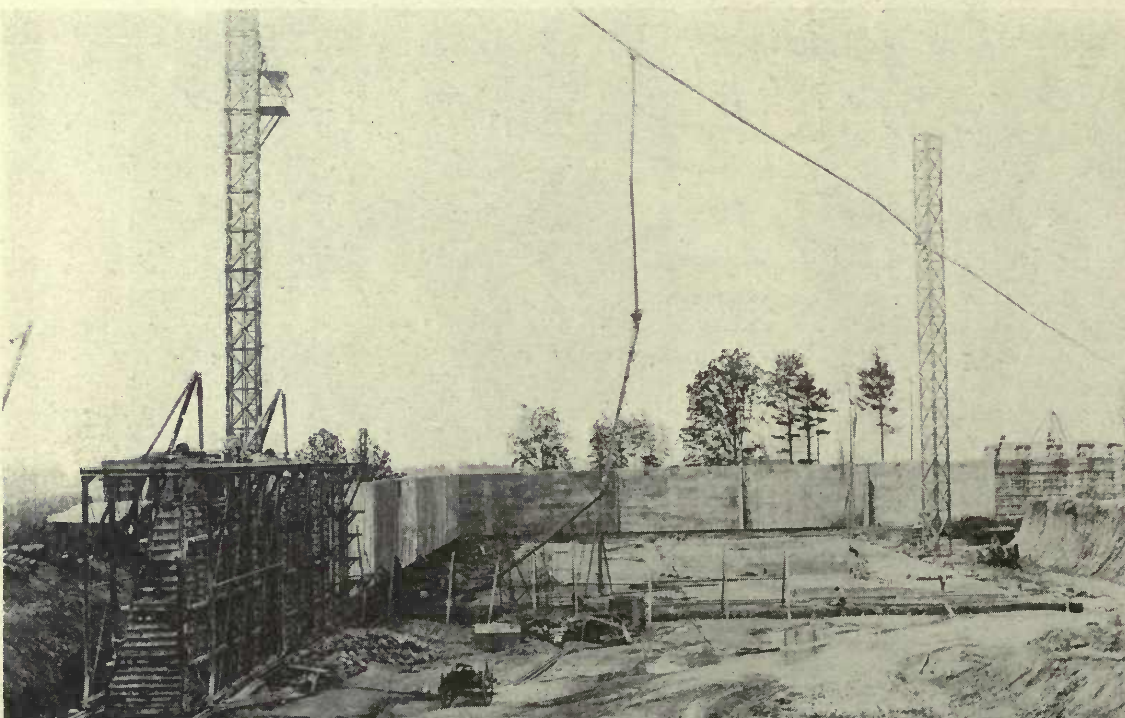
New Plant Kansas City Light and Power Co.
Sargeant & Lundy, Chicago, Architects and Engineers
Foundation Company, New York City, Contractors



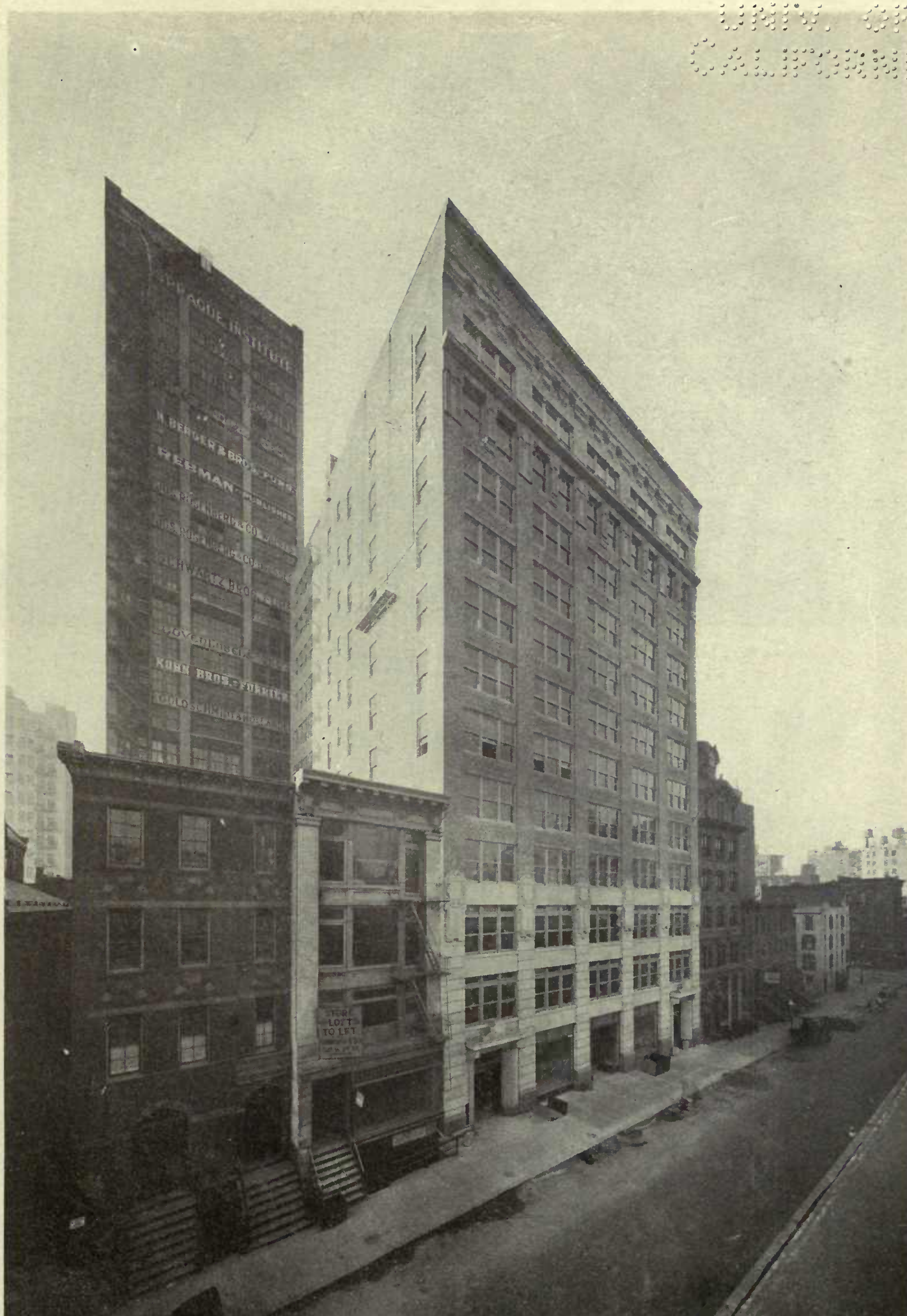
Pennsylvania Freight Terminal, Chicago, Ill.
Designed and constructed under the direction of Thos Rodd, Chief Engineer Union Station Co., Robert Trimball, Chief Engineer Maintenance of Way, Pennsylvania Lines, Geo. A. Fuller & Co., General Contractors
Truscon Waterproofing Paste, *Concentrated*, used in construction of these buildings.

Ford Motor Co., Service Building, Philadelphia, Pa.
Truscon Waterproofing Paste, *Concentrated*, used in construction of this building.

Mulford Residence, Miami, Florida. W. C. De Garmo, Architect, J. B. Orr, Stucco Contractor
Stucco waterproofed throughout with Truscon Waterproofing Paste, *Concentrated*.



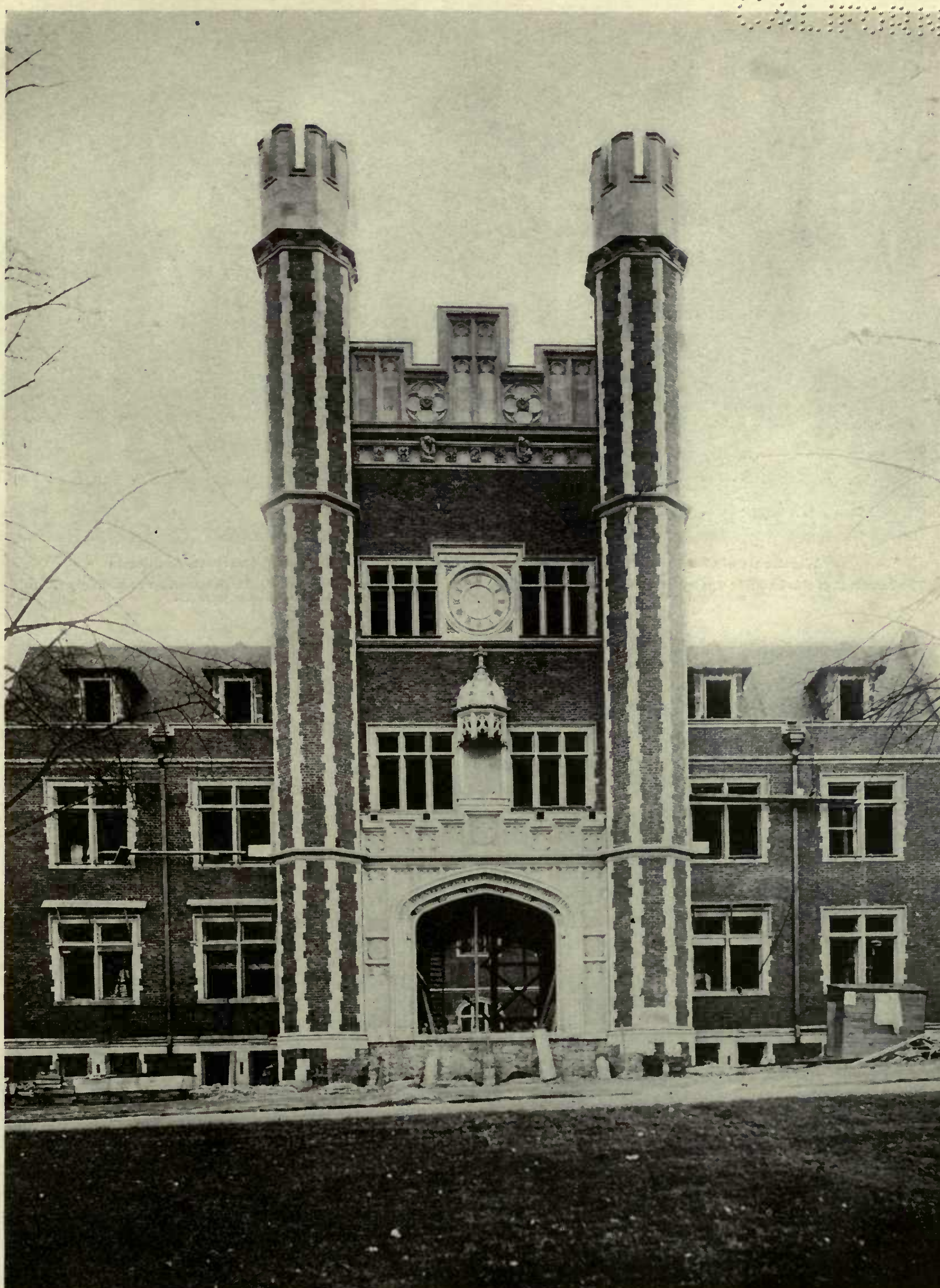
Construction of the Bevis Hill Reservoir, Schenectady, N. Y.
Capacity twenty million gallons, C. C. McWilliams, Supt. Bureau of Water, City of Schenectady. Concrete waterproofed throughout with Truscon Waterproofing Paste, *Concentrated*.



Alan Realty Building, New York, N. Y. Rouse & Goldstone, Architects, Waterproofing & Construction Co., Waterproofing Contractors
All under grade foundation work waterproofed with Truscon Waterproofing Paste, *Concentrated*.

Residence, E. C. McGraw, Miami, Florida. George C. Pfeiffer, Architect, John B. Orr, Stucco Contractor
All stucco waterproofed with Truscon Waterproofing Paste, *Concentrated*.

Residence of James MacRoberts, Miami, Florida. August Geiger, Architect, J. B. Orr, Stucco Contractor
All stucco waterproofed with Truscon Waterproofing Paste, *Concentrated*.



New Western Theological Seminary, Pittsburgh, Pa. Thomas Hannah, Architect
All concrete waterproofed with Truscon Waterproofing Paste, *Concentrated*.

Warehouse of George C. Buell & Co., Rochester, N. Y. Walker, Livingston & Brackett, Architects

The basement of this building was waterproofed with Truscon Waterproofing Paste, *Concentrated*. It withstood an exceedingly difficult practical test during the Rochester flood of 1916. See letter from architects page 57.

Rochester Sewage Disposal Plant, Rochester, N. Y.

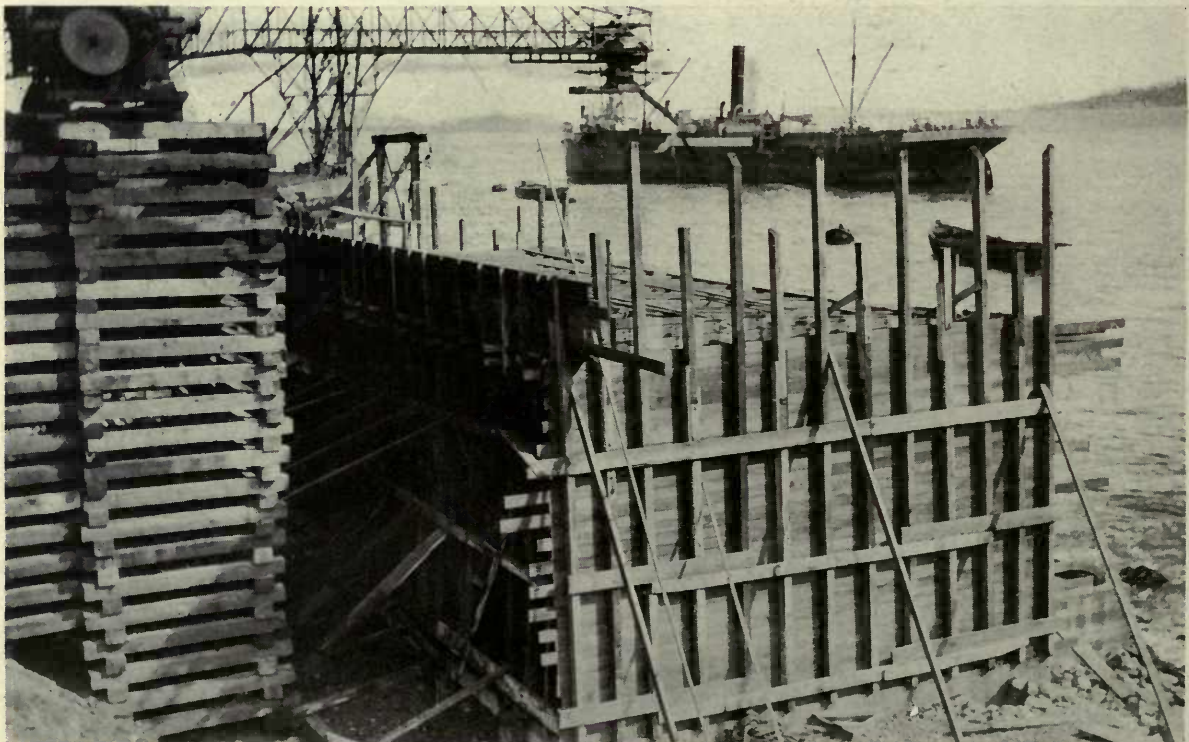
Department of Engineering, City of Rochester, Engineers C. Arthur Poole, Supervising Engineer

All concrete waterproofed throughout the mass with Truscon Waterproofing Paste, *Concentrated*.

L. G. Highbyman, Residence, Miami, Florida. August Geiger, Architect, J. B. Orr, Stucco Contractor
All stucco waterproofed with Truscon Waterproofing Paste, *Concentrated.*

Hanna Residence, Miami, Florida. August Geiger, Architect, J. B. Orr, Stucco Contractor
All stucco waterproofed with Truscon Waterproofing Paste, *Concentrated.*

Lincoln Apartments, Miami, Fa. August Geiger, Architect, J. B. Orr, Stucco Contractor, St. John Construction Co., Gen. Contractors
All stucco waterproofed with Truscon Waterproofing Paste, *Concentrated*.



Construction of concrete water tank for Bethlehem Chili Iron Mines Co., Cruz Grande, Chili. C. H. Kuster, Engineer
All concrete waterproofed with Truscon Waterproofing Paste, *Concentrated*.

Vinton Building, Detroit, Michigan. Albert Kahn, Architect, Ernest Wilby, Associate
Foundations waterproofed with Truscon Waterproofing Paste, *Concentrated.*

List of Illustrations